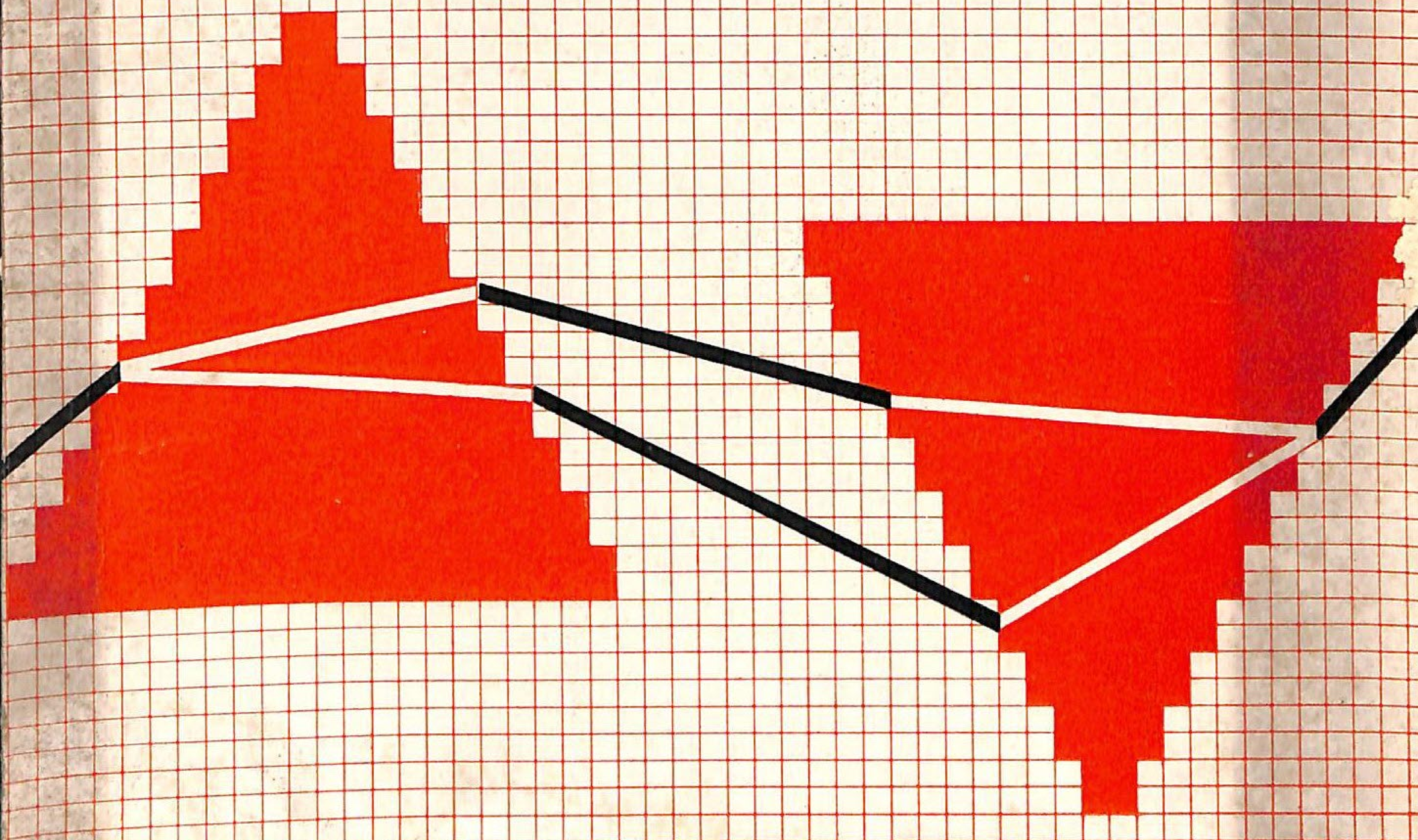
Understanding Science

PHYSICS

Class VI



Aruna Ummat • S.K. Bhargava • M.P. Chhaya

Understanding Science
PHYSICS

1

Aruna Ummat
Deptt. of Physics
Delhi Public School
R.K. Puram
New Delhi-110 022

S.K. Bhargava
Deptt. of Physics
St. Xavier's School
Raj Niwas Marg
Delhi-110 054

Editor
M.P. Chhaya
Director and Principal
Bharatiya Vidya Bhawan
Kasturba Gandhi Marg
New Delhi

Distributed by
Orient Longman

Understanding Science – Physics 1

© 1986 Sangam Books (India) Pvt. Ltd.

First published 1987
Reprinted 1988, 1989, 1990

ISBN 0 86131 653 3

Published by Sangam Books (India) Pvt. Ltd.
3-5-820 Hyderguda, Hyderabad 500 029

Distributed by
Orient Longman Limited
BOMBAY CALCUTTA MADRAS NEW DELHI
BANGALORE HYDERABAD PATNA GUWAHATI LUCKNOW

ACC NO 15528

Cover design by Ratnadeep Rudra

Design & Layout: Ratnadeep Rudra

Printed in India at
Taj Press
3024 Gali Ahiran,
B.G. Road, Delhi 110 006

Preface

At present the emphasis in science teaching is on the pupil making discoveries by investigation and on the understanding rather than on the memorization of facts. This new approach to the study of science demands the active participation of students in the learning process through experimentation. This approach leads to a proper understanding by the students of the basic concepts of science and enables them to discover new ideas.

This series has been designed to meet these needs. The efforts of the authors have been to relate, as far as possible, the teaching of science to what a student sees and does in everyday life. The thrill and excitement of doing experiments help the students to understand the subject and find something new for themselves. Students are curious; they search to understand the unknown and so an interest in learning develops. Efforts have been made here to involve the pupil, physically and emotionally, to make the learning of science a personal experience.

The language used is simple and conscise. The text has been attractively illustrated with many clearly labelled diagrams. Carefully planned out questions are given in the text to teach the pupils to reason and to arrive at logical conclusions. This gives them the much needed practice in the skills of collecting data, solving problems, applying the knowledge gained to everyday situations and, therefore, in further reinforcing their command of the subject. The experiments and activities have been carefully designed to fit naturally into their inquiry and are such that every teacher and student can perform them without difficulty.

The authors would feel happy if this series satisfies the needs of the students of the middle school classes and helps them to understand and appreciate the applications of the fundamentals of science in everyday life. Suggestions for improvement of this series would be gratefully accepted from fellow science teachers.

We would like to acknowledge our considerable debt to the authors and sources who have inspired us to write this series and to our family members and fellow teachers who have helped us all along.

January 1987

A. UMMAT
S.K. BHARGAVA
M.P. CHHAYA

Contents

Preface iii

1. **Methods of Studying Science 1**
   - *Exercises*
2. **Measurement 5**
   - Rough Estimation
   - Unit of Length
   - Unit of Mass
   - Measurement of Time
   - Multiples and Submultiples of Units
   - Area
   - Volume
   - *Exercises*
3. **Motion 14**
   - Translatory Motion
   - Rotatory Motion
   - Oscillatory Motion
   - Random Repititive and Periodic Motion
   - Speed
   - *Exercises*
4. **Force and Pressure 20**
   - Effects of Force
   - Types of Forces
   - Contact Forces
   - Forces Acting at a Distance
   - Pressure
   - *Exercises*
5. **Simple Machines 28**
   - The Lever
   - The Pulley
   - The Inclined Plane
   - The Wheel
   - The Screw
   - Care of Machines
   - *Exercises*
6. **Work and Energy 37**
   - Work
   - Energy
   - Some other Forms of Energy
   - Transformation of Energy
   - *Exercises*
7. **The Universe 43**
   - The Stars, Planets and Galaxies
   - Astronomical Distances
   - The Earth
   - The Moon
   - The Solar System
   - Comets
   - The Calendar
   - Eclipses
   - Pole Star
   - Artificial Satellites
   - *Exercises*

1

Methods of Studying Science

In the early times, human beings moved about in groups, hunting animals for meat and collecting fruits for their meals. They had to face several odds in order to survive against the wild beasts. In this fight for survival they discovered various facts which helped them face life better. They found that a sharp object could cut better than a blunt one and based upon this fact their hunting tools were improved. Fire was a chance discovery but it was a very important one. Now man could cook his meals. The discovery that a carelessly thrown away seed grows into a new plant bearing the same fruit, was the beginning of farming. The tools required for farming were designed and then improved upon.

Gradually as trade started and prospered travelling on foot became difficult. Bullocks and horses were used for covering long distances. This not only saved time but also the problem of carrying objects over a distance. These animals could draw carts as well. But again problem arose when heavy objects were to be transported over a distance. Egyptians used wooden rollers to move large heavy objects, Fig. 1.1. The objects were pushed along on the rollers which made the task comparatively easier. This observation led to the assumption that it was easier to move objects along smooth and circular surfaces. So wheels were designed and attached to carts.

The first wheels were solid discs of wood and were very heavy and the carts could not move very fast. To overcome this flaw spoked wheels were invented. Lesser amount of wood was used to make these wheels, as is seen in the Fig. 1.2. These could move much faster.

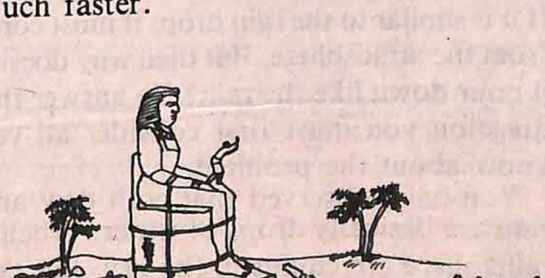
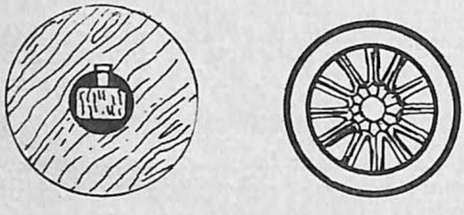


Fig. 1.1 A statue being pulled along on wooden rollers.



Solid wheels Spoked wheels

Fig. 1.2 First wooden wheels designed.

As and when the need arose new inventions were made to make life easier. But every invention was essentially based on certain observations. Different possible explanations were given to account for these observations. The explanations were then verified so that they could be used for the benefit of mankind. So we see that to arrive at some useful conclusions a systematic path must be followed. You could yourself make certain observations and carry out activities based on them and draw some conclusions from your study.

Let us consider some examples from our day to day life. Early in the morning if you take a walk in your lawn you will observe droplets of water shining on the leaves, petals and also on the grass blades. Your parents will tell you that it is dew. You must be wondering where the dew came from. If it is similar to the rain drops it must come from the atmosphere. But then why doesn't it pour down like the rain? To answer this question you must first consider all you know about the problem.

You have observed that both dew and rain are basically drops of water. When it rains there are clouds in the sky. But this is not always the case when there is dew on the grass. It may be warm when it rains but it is usually cold when there is dew on the ground. You may have seen tiny drops of water on the window glass of your school bus on a foggy day. The possible connection between and explanation for all these observations may be that the water comes out of the air. Normally you do not see the water as it is in the form of water vapour.

When the temperature falls below a certain limit this water vapour condenses to form drops of water. You may conduct an activity to verify your explanation.

Activity 1: Place the tea-kettle filled with water on a stove. Allow the water to boil. You can see the steam coming out of the snout of the tea-kettle, Fig. 1.3. Now hold a stainless steel dish in front of the steam as shown in Fig. 1.3. You will observe tiny drops of water condensing on the inner surface of the dish. As the water is converted into vapours it rises and comes out of the snout and meets the cold surface of the steel dish where it condenses. This is exactly how dew is formed.

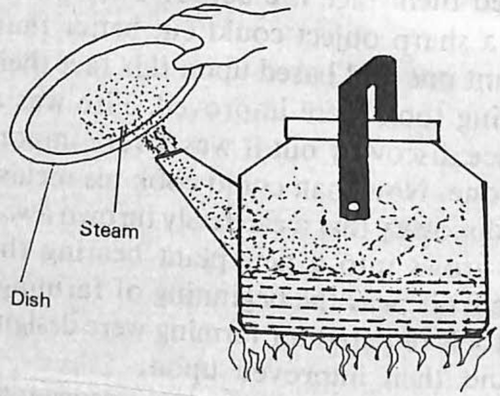


Fig. 1.3 Steam condenses on a cold surface forming water vapours.

The amount of water vapour the air can hold depends upon the temperature of the air. When the temperature rises the capacity of the air to hold the vapours increases and when the temperature falls, this capacity also reduces. The excess vapour then condenses into tiny droplets of water forming cloud, mist, fog, dew or rain. On a cold night the water vapour in the air, in contact with the cold surface of the ground condenses as tiny droplets onto the grass blades, leaves and petals. Clouds are made of a large amount of water droplets or ice particles suspended at a considerable height in the atmosphere. When this cloud passes over a region of low temperature the water droplets combine to form bigger drops. The air can no longer hold them, and they fall down as rain. So before it can rain clouds must be formed.

You observed dew-drops on the petals in your garden. This is known as **observation.** You tried to establish a connection between the dew and the rain, assuming both come from the air. This assumption is termed as **hypothesis.** Later you carried out an activity to verify the hypothesis. The process of conducting such an operation in order to verify your hypothesis is known as **experimentation.** On the basis of your experiments you arrived at some facts known as **inferences**. This systematic method of acquiring knowledge is known as **science.**

You see electic bulbs glowing in your classroom. They give you light. You have been told that these bulbs use electricity. Similarly you must have seen a tailor using a tape to make measurements before stitching your clothes. The sound of music comes from your transistor and the heat from your room heater reaches you across the room. The study of light, electricity, sound, heat and various other related common occurences, in a *scientific* manner is known as **physics.** In this book you will study about the above mentioned aspects in some details. This should enable you to understand the happenings in your surroundings better and at the same time should help you to correlate several different observations.

EXERCISES

1 What observations helped man to design wheels? ______

______

______

______

______

2. Differentiate between rain and dew. ______

______

______

______

3. Define the following:

(a) observations

(b) hypothesis

(c) inferences

(d) experimentation

4. Study the following experiments and fill in your observations and inferences, as in the example.

Experiment	*Observation*	*Inference*
i) Put a small object in front of a compressed spring attached to a hook at one end. Release the spring.	The object is pushed over a distance.	The compressed spring has the capacity to move the object.
ii) Take water in two containers. Put one over the fire and the other in the fridge.		
iii) Take water in a container with a lid. Boil the water.		

2

Measurement

In daily life people make different types of measurements every day. Here are some examples.

A tailor measures length.

A time keeper in a race measures time.

A vegetable vendor measures mass.

A milkman measures volume.

A surveyor measures area.

Observe what measurements other people around you make.

2.1 Rough Estimation

Which finger of your hand is longest and which is shortest? How do you find this out? Obviously by comparing their lengths. Similarly you can compare your height with that of your friend by standing side by side and finding out who is taller. But if your friend is in a different town, you cannot compare the heights in this way.

Our forefathers also had to measure lengths and distances. They did not have scales to measure. They used different parts of their body to measure lengths. The span, the cubit, the foot and the step were some of the widely used measures of length (Fig. 2.1).

Sometimes you have to tell your friends how tall you are, or how far your school is from your house, or how heavy your school bag is. Let us find out how we can describe these measurements.

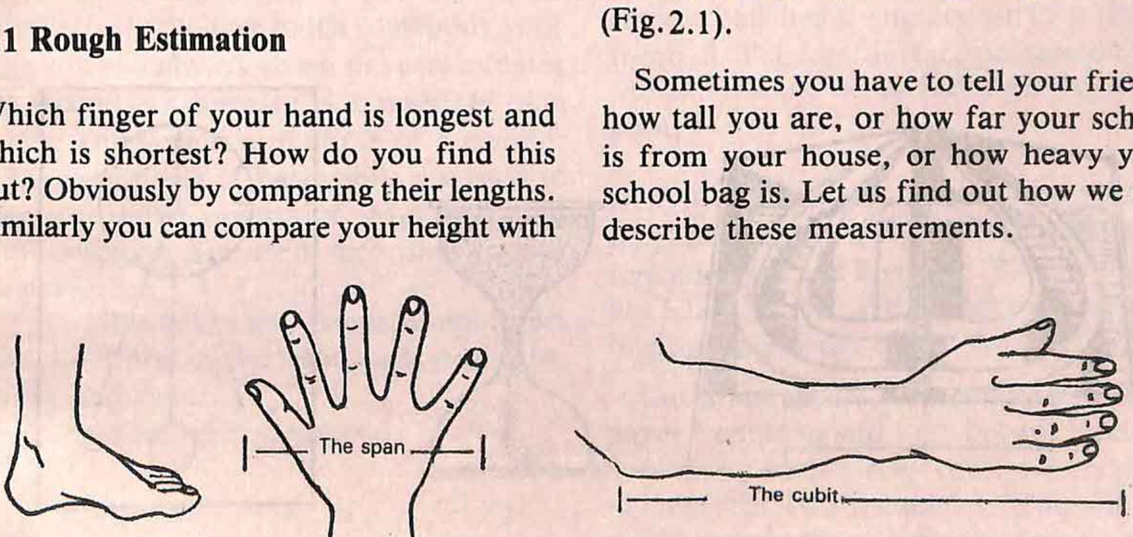


Fig. 2.1 Some early units of measurement of length.

Activity 1: Measure the length of your classroom by using your steps. Ask some of your friends to make similar measurements. Do you find the measurement to be same or different?

Different persons have different lengths of their foot or hand. So measurements taken this way differ from person to person. We therefore need some standards for measurements. The standard in which a measurement is taken is called a **unit.**

2.2 Unit of Length

Before independence we used the British units of length—mile, yard, foot and inch. France decided to use the decimal system for measurement. So French scientists designed a particular metre rod to measure length, and they called its length a **metre (m)**. This metre rod has been kept at the International Bureau of Weights and Measures near Paris. The metre is now taken as *Systeme Internationale* (S.I.) unit of length. In India a copy (replica) of this standard metre is kept in the National Physical Laboratory in New Delhi.

2.3 Unit of Mass

The standard unit of mass is **kilogram (kg).** A particular type of metallic cylinder kept at the International Bureau of Weights and Measures is the standard kilogram.

2.4 Measurement of Time

If you visit Jantar Mantar in New Delhi or Jaipur, you will find a big sun dial, which was used in ancient days to measure time (Fig. 2.2). Later on sand clocks were used but were not very efficient (Fig. 2.3). Some people still use them for measuring time for boiling eggs. However, the real advancement in the measurement of time was made when clocks were invented. A clock has a pendulum which moves to and fro at regular intervals of time (Fig. 2.4.). The principle of a pendulum was first discovered by an Italian scientist named Galileo. He, while praying in a church, noted that the chandelier of the church swung at regular intervals which were nearly the same, as measured by his pulse.

The pendulum of a clock is about 25 cm

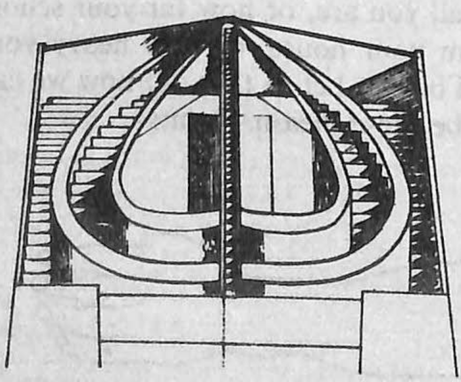


Fig. 2.2 Sun dial of Jantar Mantar was used to measure time.

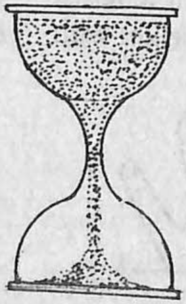


Fig 2.3 The sand clock

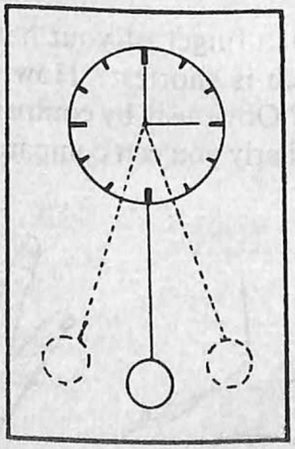


Fig. 2.4 Pendulum of a clock.

long. It swings to and fro once in one second and controls the movement of the hands of the clock. Watches have a 'balance wheel' instead of a pendulum, which serves the same purpose.

The standard unit of time is a **second.**

2.5 Multiples and Submultiples of Units

If you ask the price of ice cream the shopkeeper says that it costs 3 rupees. He does not say 300 paisa. But if you buy a balloon he says it costs 50 paisa and not ½ rupee. Similarly. if you buy wheat from a ration shop you ask for 20 kilograms of it and not 20,000 grams. But if you buy peanuts you ask for 100 grams of it and not one-tenth of a kilogram. Thus we do not always use the standard units for measurement. We use units which are most convenient. A paisa is a fraction of a rupee and so is gram a fraction of a kilogram. These fractions of a unit are called **submultiples** and are used to measure small quantities.

If you are asked the distance between Delhi and Agra you will always give your answer in kilometres and not in metres. Similarly if you have to tell somebody your age you will always give it in years and not in seconds. Kilometre is a **multiple** of a metre and year is a multiple of a second. These multiples of basic units are used to measure large quantities. Multiples and sub-multiples are used according to our convenience.

The table below gives some submultiples and multiples of the basic units of length, mass and time.

Submultiples of a metre (m)

1 decimetre (dm) $= \frac{1}{10}$ m

1 centimetre (cm) $= \frac{1}{100}$ m

1 millimetre (mm) $= \frac{1}{1000}$ m

Multiples of a metre (m)

1 decametre (dam) = 10 m
1 hectometre (hm) = 100 m
1 kilometre (km) = 1000 m

Submultiples of kilogram (kg)

1 gram (g) $= \frac{1}{1000}$ kg

1 milligram (mg) $= \frac{1}{1000}$ g

Multiples of kilogram (kg)

100 kg = 1 quintal
1000 kg = 1 metric ton

Multiples of second (s)

60 seconds (s) = 1 minute (m)
60 minutes = 1 hour (h)
24 hours = 1 day
365 days = 1 year

2.6 Area

Your reading table has smaller surface as compared to the dining table. Similarly a cricket ball has a smaller surface than a football. The total surface possessed by an object is called its **surface area** or simply **area**.

Activity 2: Draw in your notebook two rectangles as shown in Fig. 2.5. They have different lengths and breadths. Which of them has a larger area? We cannot tell unless we measure the areas of the two rectangles.

Cut a few pieces of cardboard or thick paper 1 cm long and 1 cm broad. Find out how many such pieces you have to place to cover the two rectangles. You will see that in rectangle A you can place 12 such pieces and in rectangle B, 15 such pieces. Thus we can say that rectangle B has larger area than rectangle A.

The area of the small piece of length 1 cm and breadth 1 cm is said to be **1 square centimetre** (sq. cm) or **1cm²**. It is the unit of measurement of area. Since rectangle A can accommodate 12 such pieces its area is 12 sq. cm. The area of rectangle B is 15 sq. cm. We notice that

Area of rectangle A = 6×2 = 12 sq.cm
Area of rectangle B = 5×3 = 15 sq.cm

Thus to find the area of a rectangle, we measure its length and breadth and multiply them.

Area of rectangle = Length × Breadth

The area of other figures such as a circle or a triangle can be determined by similar formulae which you will learn in higher classes.

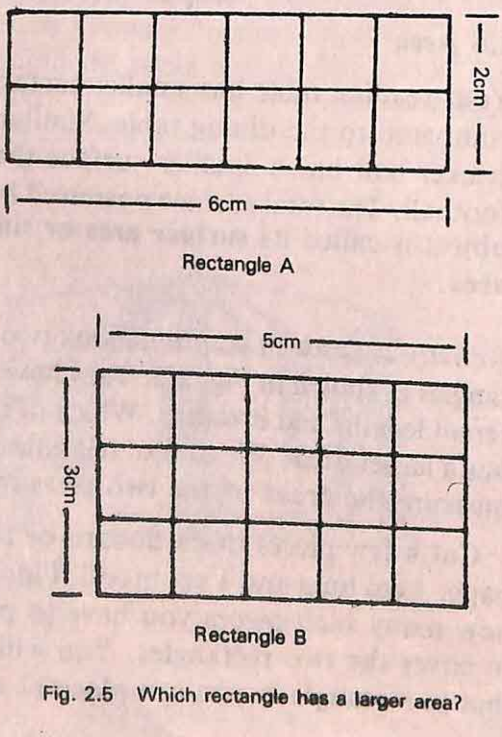


Fig. 2.5 Which rectangle has a larger area?

Area of Irregular Surfaces

Area of irregular surfaces can be found out by a graph paper. A graph paper has equal sized squares on it. Normally on a graph paper the smallest square is of 1 mm × 1 mm and has an area of 1 sq.mm.

Activity 3: *Determining area of your palm with a graph paper:* Stretch out your left hand on a graph paper and draw its outline with a sharp pencil. Count the number of 1cm × 1cm squares lying wholly within the outline (Fig. 2.6). You will notice that some small squares lie partially within the outline. If a square lies half or more than half within the outline count it as 1. If only less than half of it lies within the outline, do not count it. The total number of squares gives the area of the palm in square centimetres.

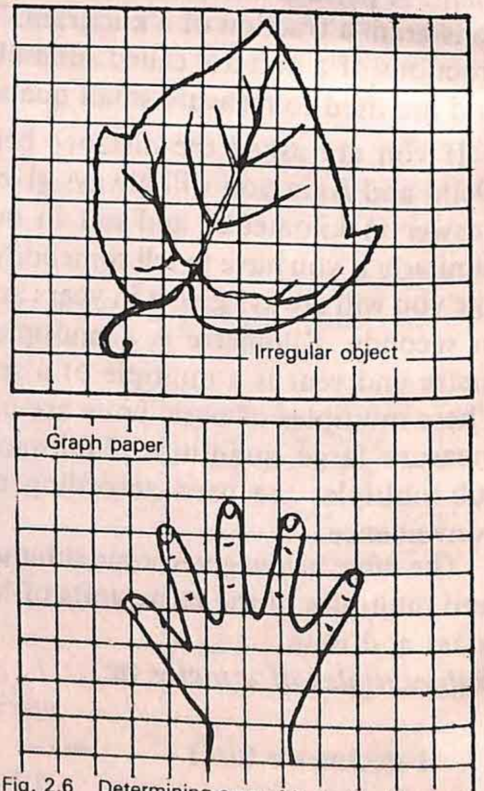


Fig. 2.6 Determining area of irregular object using a graph paper.

Suppose there are 32 full squares and 18 half or more than half squares within the outline.

Then, area = 32 + 18
= 50 sq.cm.

Similarly you can find the area of your foot or a leaf.

2.7 Volume

You will notice that the dice of a ludo is smaller than an ice cube, and that a match box is smaller than a brick. This means that a dice occupies less space than an ice cube and a match box occupies less space than a brick. The space occupied by a body is called its **volume**. A match box has a smaller volume than a brick because its length, breadth and height are smaller than that of a brick.

Activity 4: Take a book whose thickness is double the thickness of a match box. Place the book on a table. Now place match boxes by the side of the book and see how many match boxes are placed along the length of the book and how many along the breadth of the book. Now place another layer of match boxes on the first layer so that the arrangement of the match boxes looks like the book (Fig. 2.7).

Suppose 4 match boxes are placed along the length and 3 along the breadth of the book, 2 match boxes are placed along the height (thickness) of the book.

The top surface of the book needs $4 \times 3 = 12$ match boxes to cover it completely. Two layers of match boxes are needed. Therefore, $4 \times 3 \times 2 = 24$ match boxes are needed to make an arrangement which looks like the book. If, instead of match boxes, we had cubes of size $1 \text{cm} \times 1 \text{cm} \times 1 \text{cm}$ then the number of such cubes would give us the volume of the book in cubic centimetres. The volume of a $1 \text{cm} \times 1 \text{cm} \times 1 \text{cm}$ cube is **1 cubic centimetre or 1cc.**

Thus volume of a rectangular body (a cuboid)

= Length × Breadth × Height

If the length, breadth, and height of an object are measured in metres then its volume is measured in $\text{m} \times \text{m} \times \text{m} = \text{m}^3$ or cubic metres.

If the measurements of a body are taken in centimetres then its volume is measured in $\text{cm} \times \text{cm} \times \text{cm} = \text{cm}^3$ or cubic centimetres.

$$\begin{aligned} 1\text{m}^3 &= 1\ \text{m} \times 1\ \text{m} \times 1\ \text{m} \\ &= 100\ \text{cm} \times 100\ \text{cm} \times 100\ \text{cm} \\ &= 10{,}00{,}000\ \text{cm}^3 \end{aligned}$$

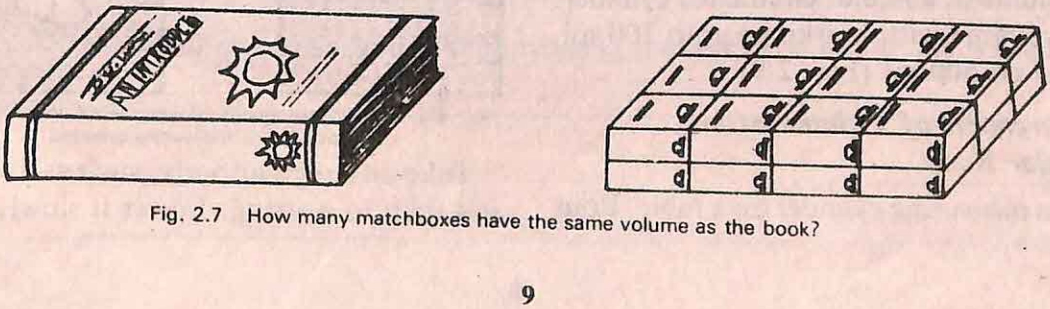


Fig. 2.7 How many matchboxes have the same volume as the book?

Volume of Liquid

A jug contains more quantity of water than a cup, because it has more space inside it than a cup. The space inside a vessel is called its **capacity.** The volume of a liquid a vessel can hold is equal to its capacity. The volume of a liquid is measured in **litres** or in **millilitres.** Millilitre (ml) is a submultiple of a litre (l).

1 litre (l) = 1000 millilitres (ml)

1 millilitre is also equal to 1 cm^3 or 1cc.

A milk bottle holds 500 ml (½ litre) of milk whereas a cold drink bottle holds 200 ml of liquid. Often standard vessels are used to measure milk, mobile oil, kerosene oil or petrol. Some of them are shown in Fig. 2.8.

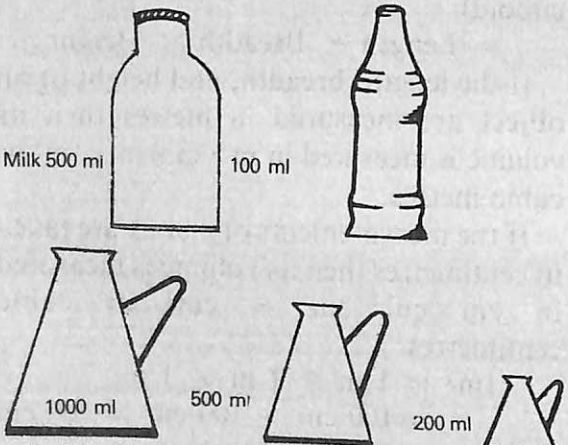


Fig. 2.8 Some containers used to measure liquids.

A cylindrical vessel made up of glass and having markings on it to measure volume of liquids, is called a **measuring cylinder** or a **graduated cylinder**. It is used to measure the volume of a liquid. Graduated cylinders are available with markings upto 100 ml, 250 ml or 500 ml (Fig. 2.9).

Measurement of Volume of an Irregular Body

Place a measuring cylinder on a table. Pour water in it. You will find that the water surface is not plain. It is curved on the sides and flat in the middle. Read the volume of water by noting the flat water surface. Take care that you keep your eye at the same level as the flat part of the water surface, as shown in Fig. 2.10.

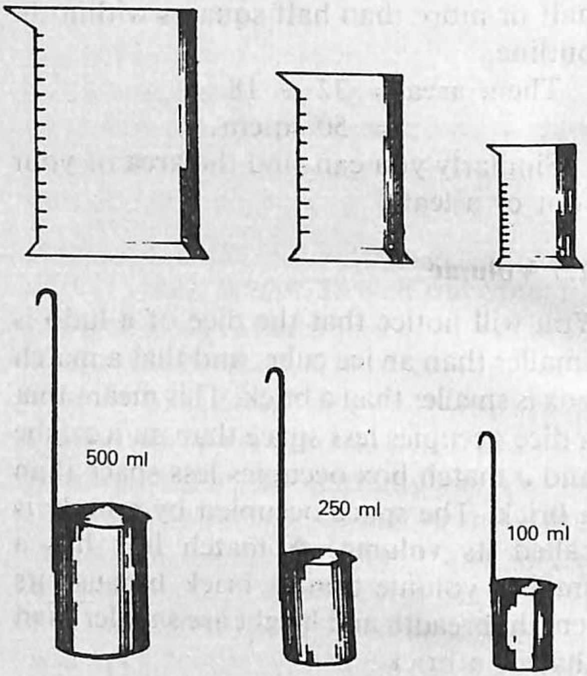


Fig. 2.9 Measuring cylinders.

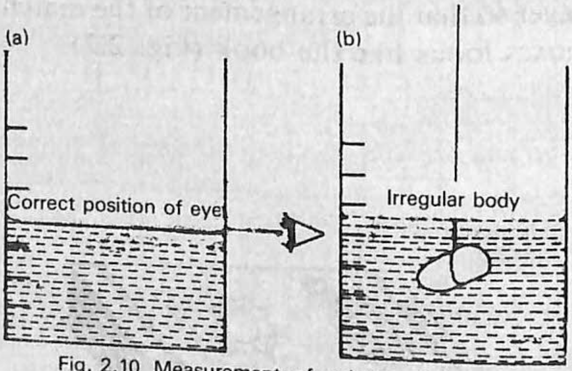


Fig. 2.10 Measurement of volume of irregular body by a measuring cylinder.

Take an irregular body, such as a stone, and tie it to a string. Lower it slowly into the cylinder till it is completely immersed in the water. Take care that the body does not touch the sides or bottom of the cylinder. You will see that the water level rises. This is because the stone occupies some space, and hence displaces water equal to its own volume. Note the water level again (Fig. 2.10b). The difference in the two readings of water surface gives us the volume of water displaced by the stone. This is equal to the volume of the stone.

EXERCISES

1. What do you understand by a unit? Name the basic units.

2. What do you mean by volume of a body? In what units is volume measured?

3. What is meant by area of a body? How would you determine the area of your foot?

4. What precaution would you take in reading the level of a liquid in a measuring cylinder?

5. How can you find the volume of an irregular solid body?__________

6. State whether the following statements are true or false.

   (i) One milligram equals $\frac{1}{1000}$ kg.

   (ii) The space occupied by a solid is called its area.

   (iii) Capacity of a vessel is measured in millilitres.

   (iv) In the metric system of units multiples of 10, 100, 1000 etc. are used.

   (v) The unit of area (m^2) is one of the three basic units.

   (vi) A millimetre is a multiple unit of metre.

   (vii) 1 cm^2 equals 100 × 100 m^2.

7. Fill in the blanks with suitable words.

   (i) Volume of liquids is generally expressed in ____________________. (m^2, litres, m^3)

   (ii) One litre equals ____________________. (1000 cm, 1000m^3, 1 cm^3)

   (iii) One decagram is a ________________ of a gram. (submultiple, multiple)

   (iv) The length of a room can be conveniently expressed in ____________. (kilometres, metres, hectares)

   (v) Volume of a spoon can be determined with the help of a ____________. (scale, graph paper, measuring cylinder)

8. Express:

4 m 540 mm in millimetres.____

637 m in kilometres.____

546 gm in kilograms.____

2 tonnes 35 kg 225 gm in grams._________________________________

3

Motion

We see bodies moving around us every day, e.g. birds flying, cars and buses moving, people walking and insects crawling. Some bodies such as an aeroplane move quite fast, whereas some bodies, such as a tortoise or an ant move quite slowly.

3.1 Translatory Motion

In all the examples given above the bodies move as a whole from one place to another. Consider the motion of a cycle shown in Fig. 3.1. The cycle as a whole moves from position 1 to position 2. The front wheel A moves to position A , the rear wheel B moves to position B′, the handle C moves to C and the cyclist D moves to D′. The distances AA′, BB′, CC′ and DD′ are all equal. So the cycle as a whole has moved from one position to another. Such a motion of the cycle is called **translatory motion.**

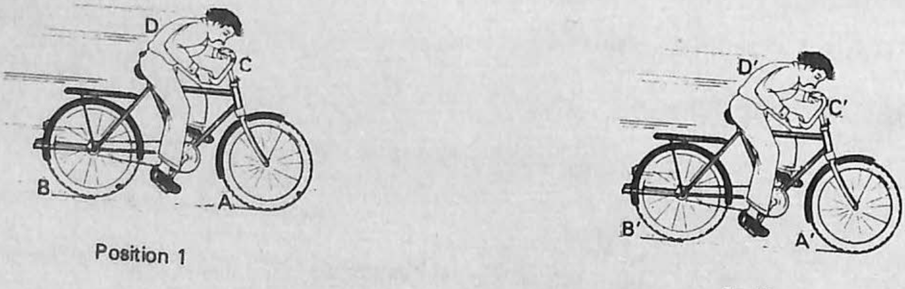
Thus in translatory motion every point on a moving body moves through the same distance in the same time.

Translatory motion can be of two types.

(i) Along a straight line (rectilinear motion).

(ii) Along a curve (curvilinear motion).

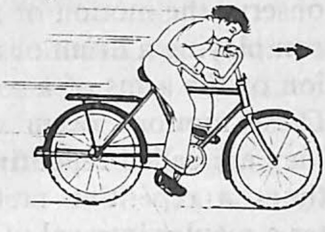
In the above example, the cycle can move in two ways. If it moves on a straight road,



Position 1

Position 2

Fig. 3.1 Translatory motion of a cycle.



(a) Rectilinear motion.

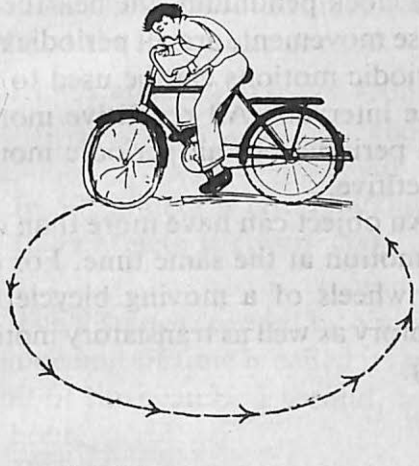
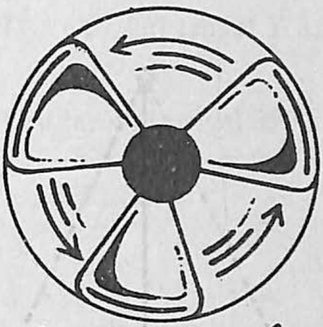


Fig. 3.2 (b) Curvilinear motion.

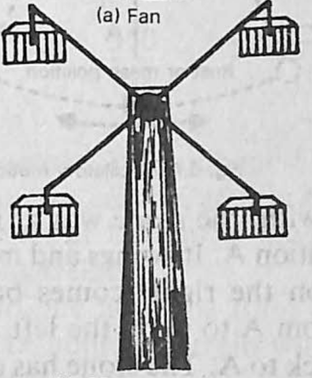
its motion is rectilinear (Fig. 3.2a). If the cyclist is taking part in a cycle race in a stadium, his cycle moves on the curved track, and its motion is curvilinear (Fig. 3.2b). In curvilinear motion the distance of the moving body from the centre of the curved path remains the same, but its direction changes continuously.

3.2 Rotatory Motion

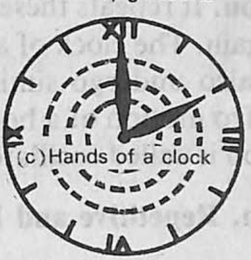
You must have taken a ride on a merry-go-round in a fair. It does not move as a whole from one place to another. It stays in one place and goes round in circles. Similar are the motions of an electric fan, a potter's wheel, a spinning top and the hands of a clock. Such a motion is called **rotatory motion.**



(a) Fan



(b) Merry-go-round



(c) Hands of a clock

Fig. 3.3 Rotatory motion.

In Fig. 3.3c you can see that as the minute hand of a clock moves, different points A, B and C on it describe different circles having the same centre. This is true of all bodies undergoing rotatory motion.

3.3 Oscillatory Motion

Activity 1: Tie a stone to a thread, about 50 cm long. Tie the thread to a stand so that the stone hangs freely. Note the position of the stone when it is perfectly still. Now give it a gentle push with your other hand. What do you notice? The stone moves to and fro about its rest position The rest position is called its **mean positior**

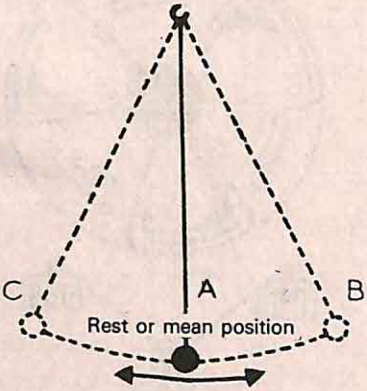


Fig. 3.4 Oscillatory motion.

To start with, the stone was at rest at the mean position A. It swings and moves from A to B on the right, comes back to A, moves from A to C on the left and again comes back to A. The stone has completed one **oscillation.** It repeats these oscillations again and again. The clock of a pendulum, or a swing also undergo similar motion. This to and fro motion of a body about its mean position is called **oscillatory motion.**

3.4 Random, Repetitive and Periodic Motion

Some motions are haphazard or irregular. For example the motion of a bee, or of a man walking through a busy market place are haphazard. They occur in all possible directions. Such motion is called **random motion** (Fig. 3.5).

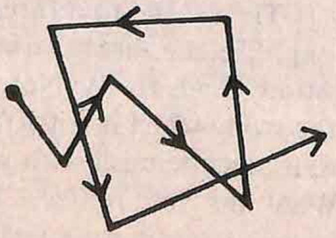
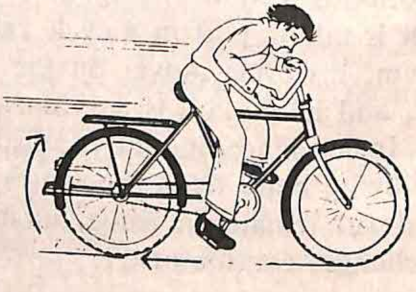


Fig. 3.5 Random motion.

Now observe the motion of the fingers of a person playing a drum or a tabla, or the motion of the arms of a soldier marching. These motions occur again and again. They are called **repetitive.**

Sometimes a repetitive motion takes place after a regular interval of time. It is then called a **periodic motion.** The motion of the Moon round theEarth, the motion of a clock pendulum, the heartbeat or the pulse movement, are all periodic motions. Periodic motions can be used to measure time intervals. All repetitive motions are not periodic but all periodic motions are repetitive.

An object can have more than one kind of motion at the same time. For example the wheels of a moving bicycle undergo rotatory as well as translatory motion (Fig. 3.6).



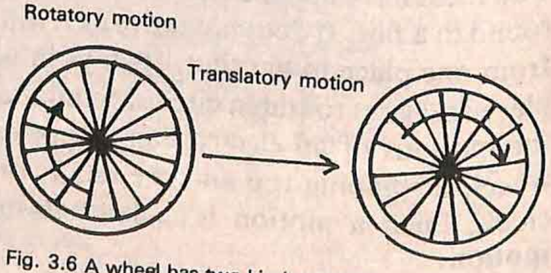


Fig. 3.6 A wheel has two kinds of motion at the same time.

3.5 Speed

Some bodies move slowly while others move fast. An aeroplane moves much faster than an ant. Let us consider two athletes A and B running a 400 metres race. If A covers this distance in 40 seconds and B covers the same distance in 50 seconds, we say A runs faster than B. If we have to compare the two athletes, we will have to find out how much distance each runs in a fixed time, say one second.

In 40s athlete A covers 400m

In 1s athlete A covers $\frac{400}{40} = 10\text{m}$

In 50s athlete B covers 400m.

In 1s athlete B covers $\frac{400}{50} = 8\text{m}$

The distance covered by a moving body in one unit of time is called its **speed.** This unit of time can be 1 second, 1 minute or 1 hour.

So athlete A runs with a speed of 10m/s (metres per second)whereas athlete B runs with a speed of 8m/s. Obviously athlete A runs faster.

The speeds of various vehicles such as cars, buses and scooters are mentioned in kilometres/hour (km/h). If on a highway a driver drives his bus at a speed of 50 km/h it means that the driver covers a distance of 50 km in 1 hour.

If in time t a body covers distance d then in unit time the body covers distance $\frac{d}{t}$

$$\text{Its speed, } s = \frac{d}{t}$$

Example 1: How long will a car take to travel a distance of 350 km if its speed is 50 km/h.

The car travels 50 km in 1 hour

The car will travel 1 km in $\frac{1}{50}$ hour

The car will travel 350 km in $\frac{1}{50} \times 350$

$= 7$ hours *Answer*

or

$$s = \frac{d}{t} \therefore \quad t = \frac{d}{s}$$

$$= \frac{350}{50} = 7 \text{ hours}$$ *Answer*

Example 2: Rajdhani Express takes 18 hours to reach Calcutta from Delhi. If it travels at 80 km/h, how far is Calcutta from Delhi?

In one hour the train covers 80 km.

In 18 hours the train will cover $80 \times 18 = 1440$ km *Answer*

or

$d = s \times t = 80 \times 18 = 1440$ km *Answer*

Table 3.1 gives an idea of the speeds of various objects.

TABLE 3.1

Object	*Speed*	
	m/sec	km/h
Man walking (average)	1	3.6
Man running (average)	5	18
Fastest man (Carl Lewis, 1984)	10.01	36.04
Fastest land animal (Cheetah)	30	108
Jumbo jet	278	1000
Sound in air	330	1188
Light	3×10^8	1.08×10^8

EXERCISES

1. (i) What do you mean by translatory motion?

(ii) Explain the two types of translatory motions?

2. Explain the difference between rotatory and oscillatory motion?

3. 'All repetitive motions are not periodic but all periodic motions are repetitive'. Discuss.

4. Indicate what type of motion each of the following is.

(i) A bullet fired from a gun.

(ii) Blades of a windmill.

(iii) A heavily drunk man trying to walk on the road.____________________

(iv) A man sitting on a chair and shaking his leg.____________________

(v) The to and fro movement of a pendulum.____________________

5. Fill in the blanks

(i) An object ____________________ (can/cannot) have more than one kind of motion simultaneously.

(ii) If I walk 500 m in 10 minutes, my speed is

(a) ____________________ m/sec

(b) ____________________ km/h

(iii) If the speed of a scooter is 50 km/h, it goes 10 km in ______________ minutes.

(iv) An aeroplane flies at a speed of 600 km/h. It covers the distance between Delhi and London in 10 hours. London is ____________________ km from Delhi.

6. Write true or false.

(i) In a body undergoing translatory motion, all parts of the body need not move simultaneously.

(ii) There is no difference between curvilinear and rotatory motion.

(iii) Rectilinear or curvilinear motion can also be periodic.

(iv) The motion of a pendulum is oscillatory as well as periodic.

(v) An object cannot have more than one kind of motion at the same time.

(vi) The time taken by a body to cover unit distance is its speed.

4

Force and Pressure

In our daily life we use forces very often. We use force to lift a weight, to kick a ball, to catch a ball, to push a box, or to run.

4.1 Effects of Force

Effect on Shape

Activity 1: Take a piece of plasticine and press it. It gets deformed, i.e. its shape changes.

Activity 2: Take a spring. Press it from both ends. It gets compressed. Pull the same spring from both ends. Its length increases. Thus application of force changes the shape of the spring.

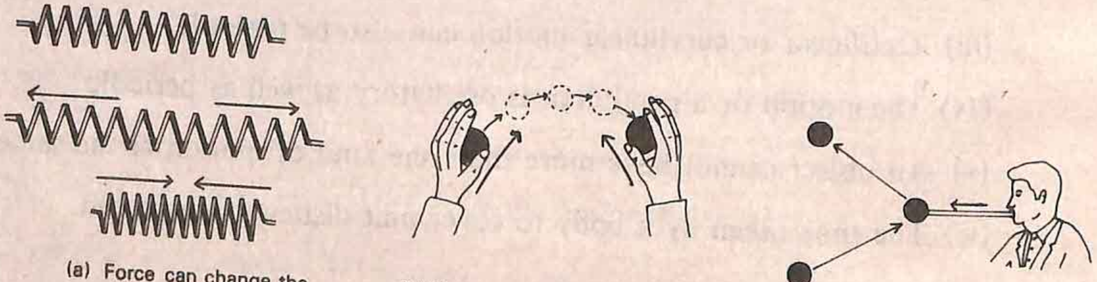
We therefore notice that *a force can change the shape of a body.*

Effect on Motion

Activity 3: Throw a ball. It goes from one place to another because a force is applied on it. Let your friend catch the ball. The ball stops, because a force is applied by your friend in a direction opposite to the direction of motion of the ball.

Thus *a force can make a body move, and can stop a moving body.*

Activity 4: Roll a table tennis ball across a table. Take a straw and blow the ball



(a) Force can change the shape of a body.

(b) Force can make a body move, and can stop a moving body.

(c) Force can change the direction of motion of a body

Fig. 4.1 Effects of force.

from the side. What do you observe?

A force can also change the direction of motion of a body.

Thus a force is something which can make a body move, stop a moving body, change the direction of motion of a body or change the shape and size of a body.

4.2 Types of Forces

When you throw a ball, your hand is in contact with the ball and exerts a force on it. You cannot exert a force on the ball if your hand is not in contact with it. However there are some bodies, for example magnets, which can exert force on another body without being in contact with it. We can therefore study forces under two general types.

(a) Contact forces

(b) Forces acting at a distance

4.3 Contact Forces

These arise as we have seen, when two bodies come in contact with each other. All forces we have discussed so far, except magnetic forces, are contact forces. These forces are exerted through solids, liquids and gases.

Friction

If we stop pedalling a bicycle, it slows down and after some time it stops. If the bicycle moves on a rough or broken road, it covers a short distance after we stop pedalling. If it moves on a smooth tar road it covers a longer distance before it stops.

In both the cases the motion of the bicycle is changed by the road. We have already learnt that a force must act to change the motion of a body. Some force, therefore, must have been exerted by the road on the bicycle to slow it down. This force is called the **force of friction** or simply **friction.**

The bicycle travels a greater distance on the smooth road than on the rough road. This seems to indicate that friction increases with roughness of the surface. Let us study this aspect of friction.

Activity 5. Take a metallic bob suspended by a thread from a stand. Place it on a table. Raise it to a particular height measured by a metre scale as shown in Fig. 4.2.

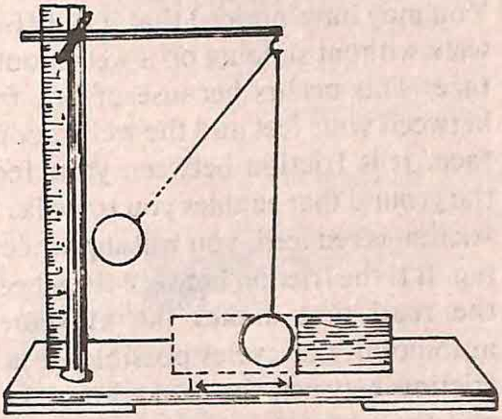


Fig. 4.2 Friction depends on roughness of the surface

Place a wooden block on the table. Release the bob. It pushes the block. Measure the distance moved by the block. Now place a glass sheet below the wooden block. Raise the pendulum to the same height and again release it. Again measure the distance moved by the block. Compare with the distance moved by the block on the wooden table. What do you find?

You will notice that the distance moved will be more over the glass sheet. Feel the surface of the table and the glass sheet with your hand. You will find that the glass surface is smoother. Therefore the opposing force of friction is less on the glass surface and the block moves a greater distance over

15528

it. The experiment can be repeated with different surfaces. We find that friction depends on roughness of the surfaces in contact. *The rougher the surface greater is the friction.*

Thus when a body moves over a surface a force of friction starts acting on it. This force is the result of the roughness of the surface and opposes the motion of the body on the surface. It increases with the roughness of the surface.

Advantages of Friction

You may have noticed that it is difficult to walk without slipping on a wet smooth surface. This occurs because of low friction between your feet and the wet smooth surface. It is friction between your feet and the ground that enables you to walk. If this friction is reduced, you will slip while walking. It is the friction between the wheels and the road that makes the movement of automobiles or cycles possible. It is again friction between the brake lining in a car and the wheel that causes the car to stop when you apply brakes.

When you rub your hands in winters they become warm. Thus friction produces heat. The surface of a match box is made rough so that heat is produced when the matchstick is rubbed against it. This causes the matchstick to catch fire. Meteors, which are big pieces of stone or rock that come from outer space, burn on entering the Earth's atmosphere due to friction between them and air. If there was no friction, the meteors would fall on the Earth and cause havoc.

Thus we see that friction is essential for us.

Disadvantages of Friction

At times if friction increases too much it becomes a nuisance.

Parts of machinery, on rubbing against each other, wear out easily. Also, fuel is wasted in overcoming friction between moving parts. We always observe that our shoe soles wear out due to friction between shoes and the ground. Tyres of vehicles wear out by constant rubbing against the road.

Reducing Friction

To reduce wear and tear of machines, we have to reduce friction. There are different ways in which friction can be reduced.

Lubrication

Lubrication means using oil. When we oil the moving parts of a sewing machine or the various parts of a bicycle, a thin film of oil is formed between the moving parts. Such a thin film offers very little friction and the moving parts of the machine move smoothly.

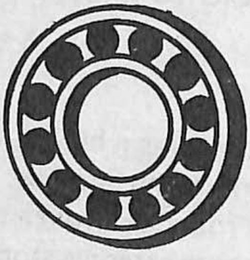


Fig. 4.3 Ball bearings reduce friction.

Ball bearings

We use small, smooth steel balls, called ball bearings in the axle of wheels, paddles of a bicycle and other moving parts of machines to reduce friction.

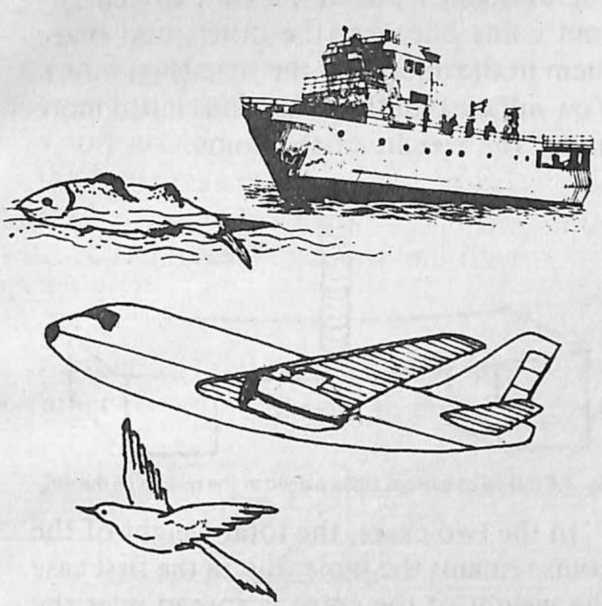


Fig. 4.4 Friction due to air and water can be reduced by streamlining.

Streamlining

Like solids, liquids and gases also offer friction. Gases offer less friction than liquids and liquids offer less friction than solids.

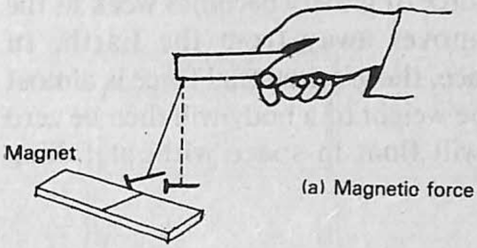
Water and air offer less friction (or resistance) to pointed objects than to flat ones. An arrow has a pointed tip so as to reduce friction between it and the air. An arrow with a flat tip will cover a smaller distance than a pointed arrow, if both are thrown with the same force.

The shapes of racing cars, aeroplanes, ships, etc. are designed in a particular way so as to reduce friction between these moving vehicles and water or air. This designing of shape of moving objects is called **streamlining.** The streamlined shape of a boat is similar to that of a fish, and the streamlined shape of an aeroplane is similar to that of birds. These shapes reduce the resistance of water or air to the moving body and the body moves smoothly.

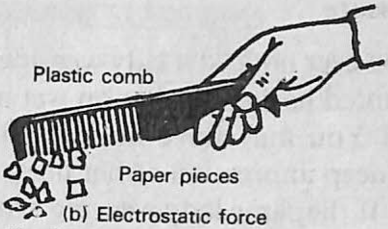
4.4 Forces Acting at a Distance

Magnetic Force

Activity 6. Suspend an iron nail with a thread. Bring a magnet near it. You will notice that the nail is attracted towards the magnet even when the magnet is at a distance from the nail. The force which the magnet exerts on the nail from a distance is called **magnetic force.**



(a) Magnetic force



(b) Electrostatic force

Fig. 4.5 Force acting at a distance

Electrostatic Force

Activity 7. Take a plastic comb. Comb your dry hair with it a number of times. Then bring it near small pieces of paper. You will notice that pieces of paper are attracted to the comb even when the comb is at a distance from the paper pieces. The force between the comb and the paper pieces is known as the **electrostatic force.**

Gravitational Force

When you throw a ball into the air what do you observe? It goes to a certain height and then falls back on the earth. Its motion is changed. We have already studied that the motion of a body is changed only when some force acts on the body. So there must be some force acting on the ball, which brings it back to the earth. This force is the pull of the earth and is called **gravitational force** or simply **gravity.** Every object on the earth experiences the force of gravity. The force by which the earth pulls a body towards itself is called the **weight** of the body. This force always acts downwards. When we lift a brick, we apply a force upwards against the pull of gravity.

The force of gravity becomes weak as the object moves away from the Earth. In outer space, the gravitational force is almost zero. The weight of a body will then be zero and it will float in space without falling down.

4.5 Pressure

Have you ever noticed a lady wearing shoes with pointed heels, walking on wet muddy ground? You may have noticed that she leaves a deep impression of her heels on the ground. If the same lady wearing flat shoes walks on the same ground, do her shoes sink by the same amount? To understand this let us perform a simple experiment.

Activity 8: Take a thin strip (about 4 cm wide) of cardboard and place it over two blocks of wood. Place about fifteen carrom coins along the length of the strip as shown in Fig 4.6a. You will see that the strip bends only slightly.

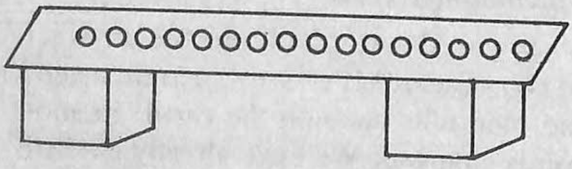


Fig. 4.6 (a) Carrom coins on a cardboard strip.

Now make a pile of the same fifteen carrom coins one over the other, and place them in the middle of the strip (Fig. 4.6b). You will see that the strip bends much more under the weight of the coins.

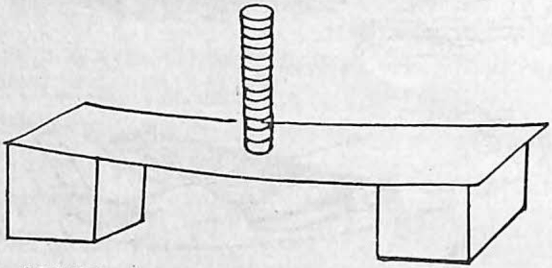


Fig. 4.6 (b) Pile of carrom coins placed in the middle of the strip.

In the two cases, the total weight of the coins remains the same. But in the first case the weight of the coins is spread over the whole strip (larger area). In the second case the total weight is acting on a part of the strip covered by one coin only (smaller area). Therefore the strip bends.

Thus we notice that the effect of a force depends not only on the magnitude of the force, but also on the area on which it is acting.

We therefore define a quantity called **pressure,** which depends on the force and the area on which it is acting.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

or Pressure is the force acting on unit area

The pressure increases if the force increases or the area on which it is acting decreases.

This explains why for the same weight of the lady, the pointed heels of the shoes sink into the soft ground, much more than the flat shoe. The same weight is spread over a smaller area in case of the pointed heels. Hence the pressure is high and the heels sink into the ground.

War tanks move on steel tracks. These tracks have a large area and thus the pressure of the heavy tank on the ground is reduced. This enables the tank to move even on soft ground without sinking.

For the same reason, buses and trucks have broad and double wheels so that the pressure on the tyres is reduced and they do not burst, Fig. 4.7.

It is easier to drive a sharp nail into wood rather than a blunt one. In the case of a sharp nail the force applied on the nail is concentrated on the small area of the pointed tip of the nail. In the case of a blunt nail, the same is spread over the larger area of the blunt tip. Hence the pressure in the case of a blunt nail is reduced and it becomes difficult to drive it into wood.

Cutting tools and knives have very sharp edges so that the force applied by hand can exert a large pressure on the sharp edge of the knife. This helps in cutting objects more easily.

Fig. 4.7 Broad double wheels reduce pressure on tyres of buses and trucks.

EXERCISES

1. What is meant by 'force'? ______________________

____

____

2. Name the effect produced by a force in the following cases.

(i) When a football player kicks the moving ball to deflect it. ______________

(ii) The sling of a rubber catapult is stretched. ______________

(iii) Brakes are applied by a cyclist. ______________

(iv) A spring is compressed. ______________

(v) A man pushes a heavy cart. ______________

3. Name the type of force acting in the following cases.

(i) A cyclist stops pedalling and the bicycle comes to rest slowly.

(ii) Two balloons rubbed together and suspended near each other, push each other even when not in contact.

(iii) A stone is dropped from a height.

4. Give at least three advantages of friction.

5. What are the disadvantages of friction?

6. Name the different ways of reducing friction.

7. Define pressure.

8. What is the difference between force and pressure ?

9. Give reasons for the following.

(i) It is easier to cut with a sharp knife than with a blunt one.

(ii) The foundation of a building is always made wider than the building itself.

(iii) It is painful to walk bare foot on small pebbles.

10. How does pressure change with:

(i) increase in force?

(ii) increase in area of the surface on which force acts?

11. State true or false.

(i) Force of friction acts in the direction of motion of a body.

(ii) Air exerts force of friction.

(iii) When a body rolls on a surface it experiences less friction than when it slides on the surface.

(iv) Corrugated tyres of automobile wheels avoid skidding of vehicles.

(v) We will find it much easier to walk if there were no friction between our feet and the ground.

5

Simple Machines

You must have observed that if the lid of a tin is tightly closed and we cannot open it with our finger-nails, it can be opened with the handle of a spoon. We cannot open a tight nut with our fingers but use a spanner instead. A trolley is used at a railway station or an airport to carry heavy load, which cannot be lifted or pushed single handed. A crane is used to lift heavy machinery in factories.

In all these cases we use devices that makes it easier for us to do the required job.

There are indeed many instances we come across in our daily life where the work is beyond the ability of a single person to do, but the use of a simple device makes the work much simpler. A device which makes work easier for us, usually by overcoming a large resistance using a small force, is called a **machine**. Let us now study about some of the simple machines used in our daily life.

5.1 The Lever

A lever is a simple machine. In its simplest form it consists of a rigid bar supported at some point, called the **fulcrum.** We use

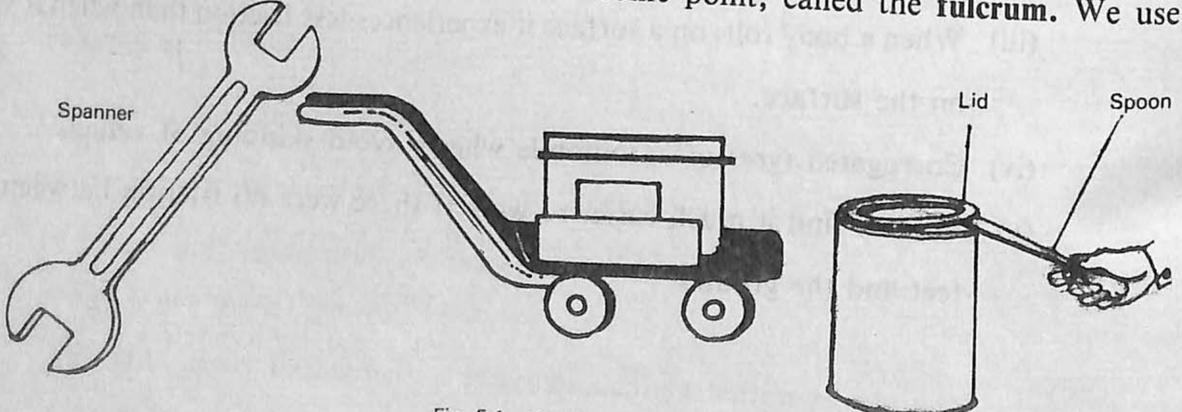


Fig. 5.1 Machines in action.

various types of levers in our daily life. To understand its working let us perform an experiment.

Activity 1: Take a metre scale and support it on a sharp wedge (a triangular support with a sharp edge) so that it is horizontal. The point of support is the fulcrum. Place a one rupee coin on one side of the scale close to the support. The coin has weight and it turns the metre scale around the point of support. Now place a ten paisa coin, which is lighter than the rupee coin, on the other side of the scale. Adjust its position from the fulcrum in such a way that the two coins balance the scale horizontal again,Fig. 5.2.

What do you observe? You will notice that the ten paisa coin has to be placed much further away from the fulcrum as compared to the rupee coin. Why is it so? A ten paisa coin is lighter in weight as compared to a rupee coin. A lighter weight placed further from the fulcrum produces the same turning effect as a heavier weight of a rupee coin placed nearer to the fulcrum. Thus we can use a lighter weight to balance a heavier weight by using a lever.

If we have to shift a heavy stone or a box we simply use a long iron bar called a crowbar which can turn about a fulcrum (Fig. 5.3b). From the above activity you should be able to understand how the crowbar is used in shifting a heavy load.

The force applied to shift the **load** is called the **effort**. If the load is heavy, the effort is applied much further away from the fulcrum. So the effort applied is much less than the load to be raised. Thus *by use of lever as a simple machine, we gain in force.*

The positions of the effort, load and fulcrum can change. Accordingly, we have three types of levers.

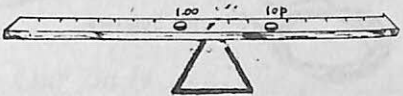
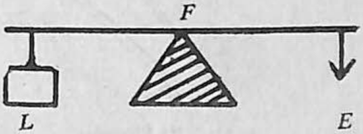


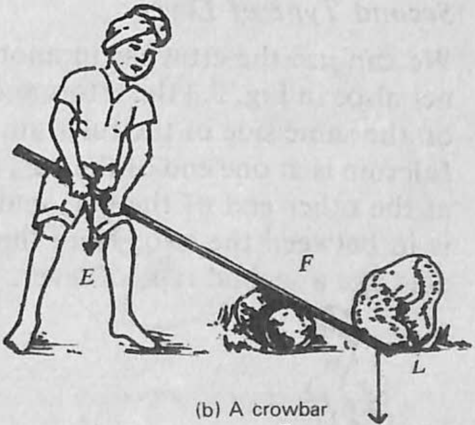
Fig. 5.2

First Type of Lever

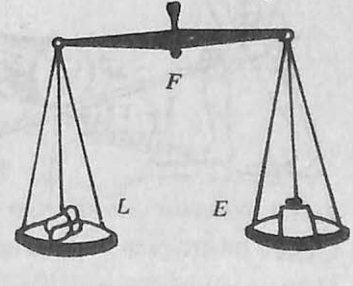
In this type of lever, the fulcrum is in between the load and effort. The crowbar is a first type of lever. Other levers of this type are beam balance, scissors, see-saw, pincers etc. (Fig. 5.3).



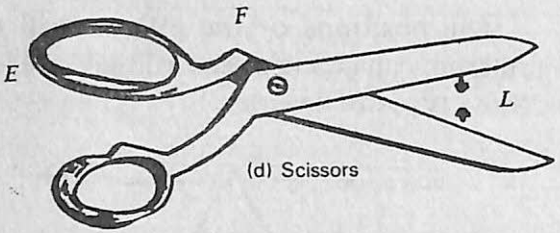
(a) The fulcrum is in between the load and effort



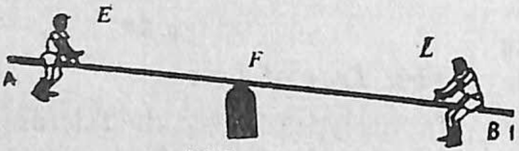
(b) A crowbar



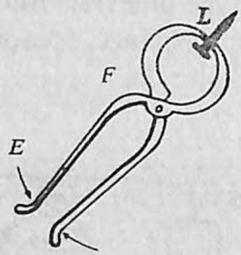
(c) Beam balance



(d) Scissors



(e) See-saw



(f) Pincers

Fig. 5.3 First type of lever

Second Type of Lever

We can use the crowbar in another manner also. In Fig. 5.4 the effort and load act on the same side of the fulcrum. Here the fulcrum is at one end of the bar, the effort at the other end of the bar, and the load is in between the two. Here the crowbar acts like a second type of lever.

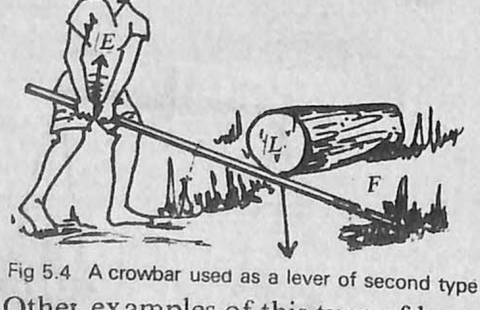
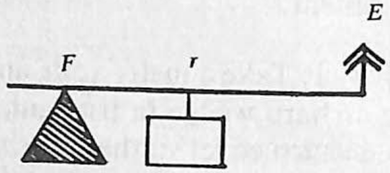
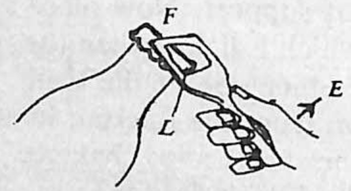


Fig 5.4 A crowbar used as a lever of second type

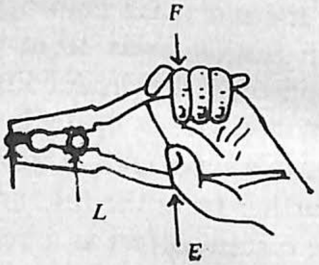
Other examples of this type of lever are: lemon squeezer, bottle opener, nut cracker, wheel barrow etc (Fig. 5.5).



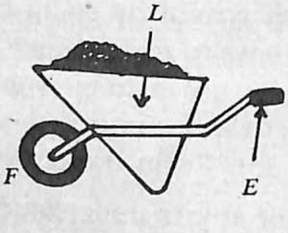
(a) The fulcrum is at one end, the effort is applied at the other end and the load is in between the two



(b) Bottle opener



(c) Nut cracker

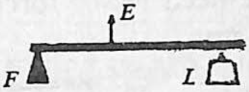


Wheel barrow

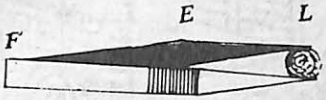
Fig. 5.5 Second type of lever.

Third Type of Lever

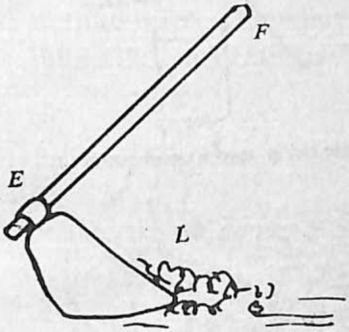
In the third type of lever, the fulcrum is at one end, the load at the other end and the effort is applied in between the fulcrum and the load. Sugar tongs, forceps, knife etc. are examples of third type of lever (Fig. 5.6).



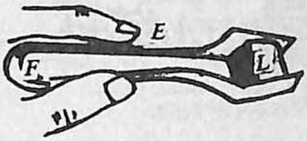
(a) The effort is applied in between the load and the fulcrum



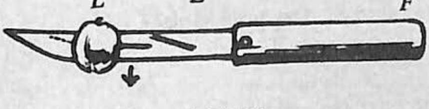
(b) Forceps



(c) Shovel



(d)Sugar tongs



(e) Knife

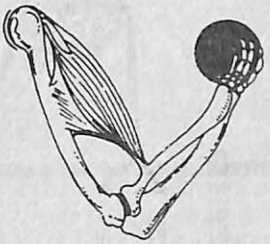
Fig. 5.6 **Third type of lever**

Notice that in this type of lever the effort is nearer to the fulcrum than the load.

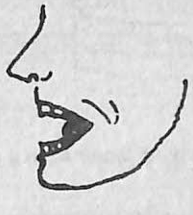
Therefore, you have to *apply a greater force to overcome a small load. This is very useful in certain situations, for example while using forceps for lifting small delicate objects.*

Levers in Our Body

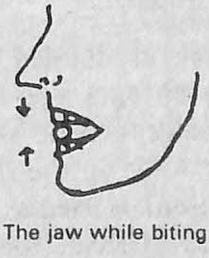
Some parts of our body also operate on the principle of levers. The human arm is a lever of third type as shown in Fig. 5.7a. When we chew something our jaw acts like a lever of the second type,. whereas when we cut something hard with our front teeth, then our jaw acts like a lever of the third type (Fig. 5.7 c).



(a) The arm



(b) The jaw while chewing

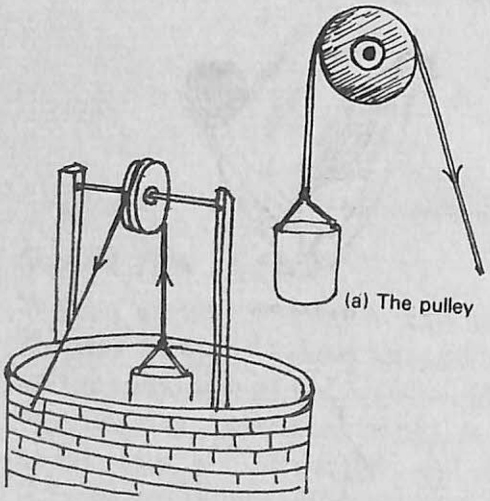


(c) The jaw while biting

Fig. 5.7 Levers in our body.

5.2 The Pulley

If we want to take out water from a well with a bucket, it will be very difficult to pull the bucket vertically upwards. You must have observed that it is much easier to pull the bucket using a grooved wheel over which rope passes. Such an arrangement is called a **pulley**. Here the effort is applied downwards rather than upwards. The *effort applied is not less than the load to be lifted but only the direction of the force is changed by the use of the pulley*. Thus a machine can help us to do work more easily even if we do not gain force by using it.



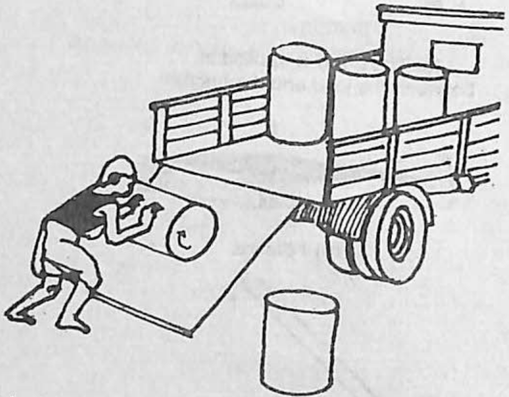
(a) The pulley

(b) A pulley used to draw water from a well

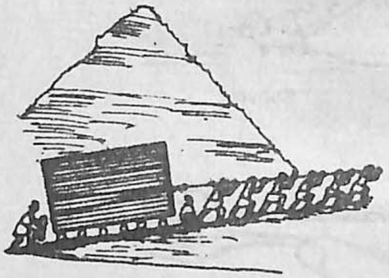
Fig. 5.8 The pulley helps us by changing the direction of force applied.

5.3 The Inclined Plane

When heavy barrels are loaded in a truck they are rolled up along a wooden plank. One end of the plank rests on the edge of the truck and the other on the floor. This slanting wooden plank is used as an **inclined plane.** It is very difficult for a person to lift the heavy barrel, to be loaded in the truck. An inclined plane makes the work easier. So an inclined plane is also a machine. If the slope is steep, we need greater force to push the load up. If the slope is gradual, we need lesser force to push the same load up.



(a) An inclined plane being used to load barrels in a truck.



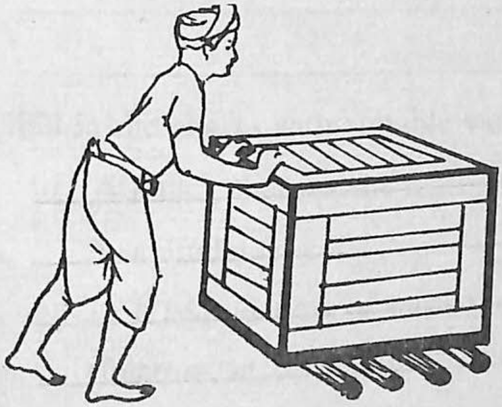
(b) The gradual slope of mountain roads makes it easier to climb up.

Fig. 5.9 The inclined plane

For the same reason it is much difficult to climb a steep hill. Therefore on a hill station, roads are constructed to have gentle slope. No doubt, we have to travel a larger distance but we have to apply less force to climb the mountain along the road.

5.4 The Wheel

If we have to shift a heavy box, we find it very difficult to slide it. When we place wooden rollers under the box we find it easier to shift the box (Fig. 5.10). This happens because the friction experienced by a body rolling over a surface is much less than that experienced by a sliding body. Thus the rollers have lesser friction with the ground than the box. In other words *rolling friction is less than sliding friction.* This should help you understand why all our vehicles move on wheels and why ball bearings are used to reduce friction in moving parts of machines. The wheel is one of the most important inventions of early man.



(a) Rollers make it easier to move heavy objects.

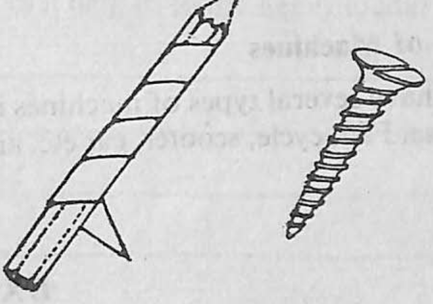
(b) Vehicles move on wheels.

Fig. 5.10 Wheels

5.5 The Screw

A screw is a modified form of inclined plane. This can be seen from the following activity.

Activity 2: Cut a plane paper in the form of a right angled triangle. Its slanting surface is the inclined surface. Now wind the inclined surface on a round pencil. This wrapped paper will look like the thread of a screw (Fig. 5.11).



The screw is a modified form of an inclined plane.

Fig. 5.11 The screw.

A screw jack is a machine having a screw and a lever in combination. It is used to lift up heavy objects such as a car or a truck (Fig. 5.12).

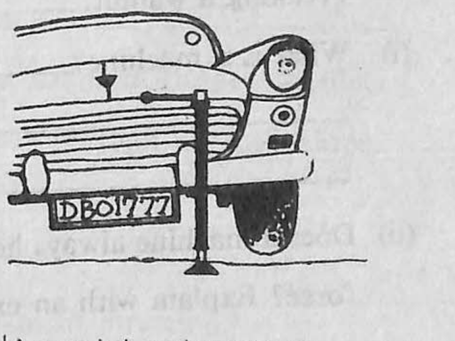


Fig. 5.12 | A screw jack can be used to lift up vehicles.

These are some of the very simple machines. If you visit a factory or an industry you do not always find such simple machines. The big machines you see in factories are combinations of various types of levers and other simple machines. Just as you can make so many words using the alphabets of a language, similarly you can make various types of machines using the simple machines you now know about. A crane, for example, contains levers, wheels, and pulleys.

5.6 Care of Machines

You will have several types of machines in your house. Fan, cycle, scooter, car etc. are all machines very useful to us. We should take proper care of them.

We should keep the machines clean and free of dust. Some parts of machines are made up of iron and can rust. We should have them painted to prevent them from rusting.

We have learnt that friction causes wear and tear of machine parts. To reduce friction we should lubricate the machine parts and thus prolong the life of a machine.

Activity 3: One machine you can study very easily is your bicycle. Try to find out what type of simple machines it is made of.

EXERCISES

1. (i) What is a lever? ____________________

____

____

____

(ii) Classify the following into various types of levers.

(a) Pliers (b) Tongs (c) Your foot while kicking a football (d) A jaw while breaking a walnut.____________________

2. (i) What is a machine?____________________

____

____

(ii) Does a machine always help us to overcome a large load by using a small force? Explain with an example. ____________________

____

3. How do wheels help in moving heavy objects? ________

4. A pulley does not help us gain force. How then does it help us to lift heavy loads?

5. Fill in the blanks with suitable words.

   (i) A pulley changes the ________ of force. (direction, magnitude)

   (ii) In a second type of lever the ________ is in the centre. (fulcrum, effort, load)

   (iii) A lever of third type helps us to ________ force. (lose, gain)

   (iv) A fat boy should sit at a ________ distance from the fulcrum whereas a thin boy should sit at a ________ distance from the fulcrum to keep the see-saw balanced. (larger, smaller)

   (v) It is ________ to climb a steep slope than a gentle slope. (easier, difficult)

6. State true or false.

   (i) A pulley is used for applying force in a convenient direction.

   (ii) A wheel barrow is a lever of first type.

(iii) Force is gained in an inclined plane.

(iv) Too much friction between the parts of a machine damages it.

(v) A bicycle is a simple machine.

(vi) Sliding friction is less than rolling friction.

6

Work and Energy

6.1 Work

If you study continuously for two hours sitting in a chair you feel tired. You say that you have done a lot of work. If you stand for a long time with a heavy weight in your hand you feel tired. But in the above two cases, in the language of Physics, you have not done any work! Similarly if you push a wall or a heavy box which does not move, you may sweat but you have done no work. In the language of Physics, *work is done only if a force acts on a body and the body moves under the action of that force* (Fig. 6.1).

We do work when we pull out a bucket of water from a well. Here the bucket moves against the force of gravity. We do work if we push a lawn mower. Here the mower moves against the force of friction. We also do work against the force of gravity when we climb up stairs.

Suppose you move a box through a distance of 1m. You do a certain amount of work against the force of friction. Now if you move the same box through 2m, obviously, you will do double the work. Similarly if you move a box of double the weight through 1m, you do double the

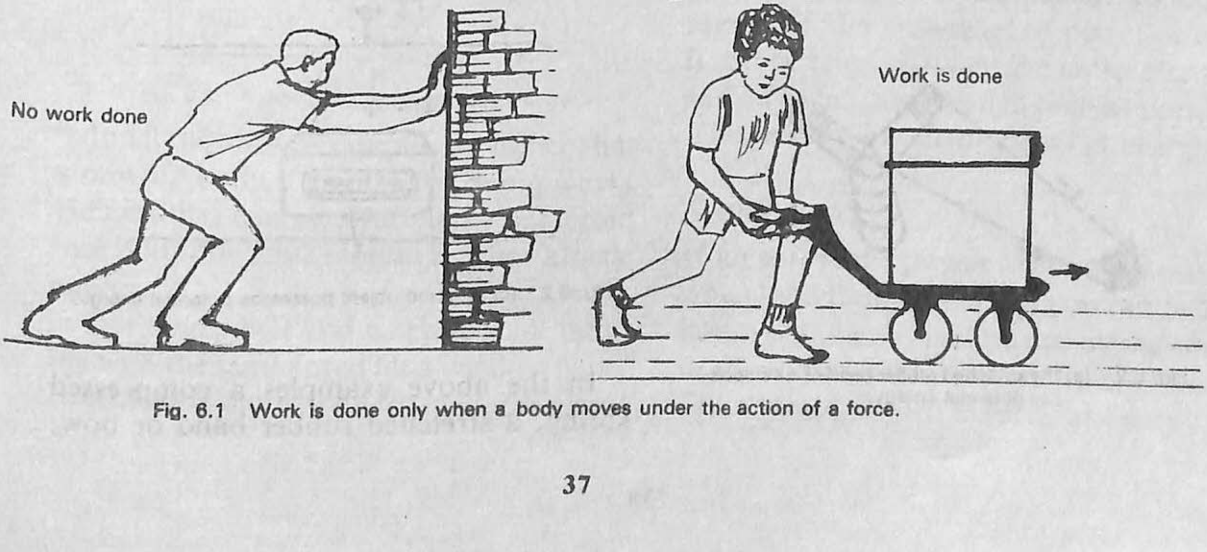


Fig. 6.1 Work is done only when a body moves under the action of a force.

work. This means that work done increases with increase in force applied, and it also increases with increase in distance moved by the body.

Work is measured by the product of the force and distance moved by the body in the direction of the force.

Work done = Force × Distance

or $W = F \times S$

6.2 Energy

Your parents ask you to take a glass of milk and to eat something before you leave for school so that you feel active and energetic to do the day's work. When you come back from school, or after a hard game, or a long run, you feel exhausted, and feel as if there is no energy left in you. You feel that you have no capacity to do any more work.

Energy is the capacity of a body to do work.

Potential Energy

When you wind the spring of a toy and leave it on the ground, it starts moving. A stretched rubber band of a catapult can throw a pebble with great speed (Fig. 6.2a). A stretched bow can shoot an arrow.

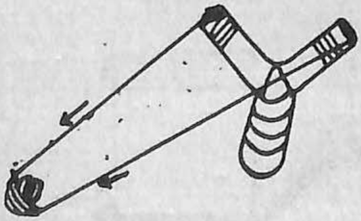


Fig. 6.2 (a) The stretched rubber band of a catapult has potential energy.

Activity 1: Take a strong spring and place it on a table. Compress the spring and place a ball very close to the spring. Release the spring. What do you observe? The spring hits the ball and displaces it (Fig. 6.2b). Nothing would have happened to the ball if the spring had not been compressed. This means that the spring in the compressed form has the capacity to do work, i.e. it possesses energy.

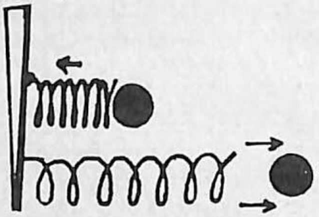


Fig. 6.2 (b) A compressed spring possesses potential energy.

Activity 2: Take a long nail or a peg and drive it partly in soft ground. Take a brick, raise it to a certain height and drop it on the nail. It drives the nail more into the ground (Fig. 6.2c). Thus a raised brick has the capacity to do work, i.e. it possesses energy.

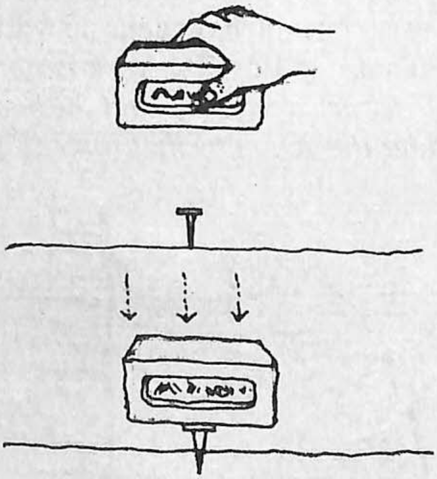


Fig. 6.2 (c) A raised object possesses potential energy.

In the above examples a compressed spring, a stretched rubber band or bow, and a brick at a height possess energy due to their state of position. The energy they possess is called **potential energy.**

In Activity 2 if we take a heavier brick and drop it from the same height, the nail will be driven to a greater depth. Also if the same brick is dropped from a greater height , the nail will be driven more into the ground. This shows that the *potential energy of a raised body depends upon the mass of the body, and the height of the body from the ground.*

Kinetic Energy

A moving bullet pierces a block of wood. A moving striker hits a carrom coin and makes it move. A moving engine pulls a train.

Activity 3: Take an inclined surface. Take a cylindrical tin (an empty jam tin will do). Place a ball at the foot of the inclined surface. Roll the tin down the inclined plane. What do you observe? The tin displaces the ball (Fig. 6.3).

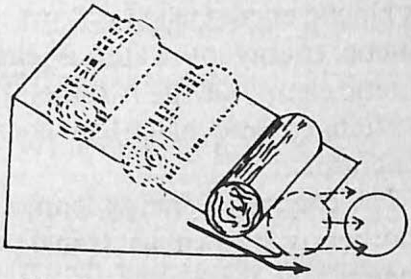


Fig. 6.3 A moving object possesses energy.

In all the above examples we notice that a moving body is capable of doing work. Hence it has energy. The energy possessed by a body due to its motion is called **kinetic energy.**

If a tennis ball and a cricket ball moving with the same speed hit a window pane, which ball is more likely to smash the glass? Obviously the cricket ball because it is heavier. Thus the cricket ball possesses more kinetic energy than the tennis ball due to its greater mass. Thus kinetic energy of a body depends upon its mass; *greater the mass, greater is its kinetic energy.*

A bullet shot from a rifle can pierce a thick wall whereas a stone of the same mass cannot. This is because the bullet is fired at a very high speed. Thus kinetic energy depends upon the speed of the body. *Greater the speed of the body, greater is its kinetic energy.*

Potential and kinetic energy are known as **mechanical energy.**

6.3 Some other Forms of Energy

Besides kinetic and potential energy, energy can exist in various forms. Some of them are as follows.

Heat Energy

The heat produced by burning of petrol in a car engine or burning of coal in a steam engine drives the car, or the engine. Thus heat is a form of energy.

Chemical Energy

When petrol is burnt it gives heat energy. But where does this energy come from? How is it stored in the petrol? Energy is present in the molecules of petrol or coal. It can be released when the molecules take part in a chemical change such as burning. This energy is called **chemical energy.**

Sound Energy

If an aeroplane passes over your house or when loud thunder occurs, you can feel the house shaking. This is caused by the energy in the sound of the aeroplane or thunder. Thus sound is also a form of energy.

Light Energy

Light is also a form of energy. However, light does not normally have enough energy to move objects.

Electrical Energy

When you switch on an electric bulb it gives out heat and light energy. This energy is derived from the flow of electric current in the bulb. The energy present in electric current is known as **electrical energy.**

Atomic Energy

You know that all elements are made of atoms. These atoms have a lot of energy stored in them. This energy is used in atomic power stations, such as the one at Trombay, to produce electricity. Huge amounts of atomic energy is released during the explosion of an atomic bomb (Fig. 6.4). Even the sun gets its heat and light energy from atoms.

6.4 Transformation of Energy

When you rub your hands they become warm. Here, mechanical energy spent in rubbing your hand is converted into heat energy. When you switch on a bulb, electrical energy is converted into light energy. When we burn coal, chemical energy of fuel (coal) changes into heat energy.

At the nuclear power plant in Trombay atomic energy is utilized to give light, heat and electrical energy.

At hydraulic power station, water is thrown from a great height on the vanes of a turbine and causes it to rotate. This in turn rotates the **coil** of the generator and produces electricity. What energy changes take place in this case? At a height water has potential energy which is converted into its kinetic energy when it flows down. This kinetic energy of water is changed into kinetic energy of the turbine. This in turn is changed into electrical energy by the generator.

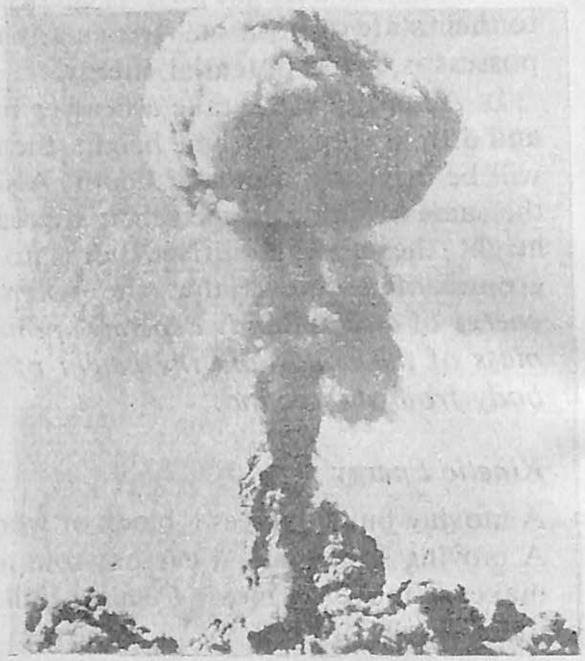


Fig. 6.4 An atomic bomb explodes.

The change of energy from one form to another is known as **transformation** of energy.

If you study different phenomena in nature, you will see that in every phenomenon transformation of energy from one form to another takes place.

EXERCISES

1. State whether work is done or not in the following cases.

   (i) A boy pushing a wall.

   (ii) A boy pushing a chair from one corner of a room to another.

   (iii) A weightlifter lifting up a heavy weight.

   (iv) A boy throwing a stone at his friend.

2. (i) What is energy? ______________________________

   ____

   (ii) Indicate whether the following will have kinetic energy, potential energy, both or none of these.

   (a) A flying bird. ______________________________

   (b) A parrot perched on a tree. ______________________________

   (c) A ball lying on the ground. ______________________________

   (d) A speeding car. ______________________________

   (e) A train standing at a railway platform. ______________________________

   (f) The wound spring of a watch. ______________________________

   (g) Hands of a clock. ______________________________

3. (i) Which ball in Fig 6.5a has more kinetic energy? Both are moving with the same speed. ______________________________

   (ii) Which ball in Fig 6.5b has more potential energy? ______________________________

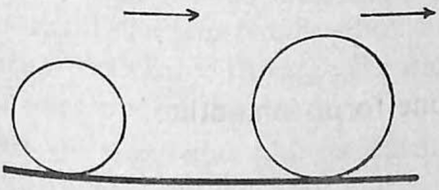


Fig. 6.5 (a)

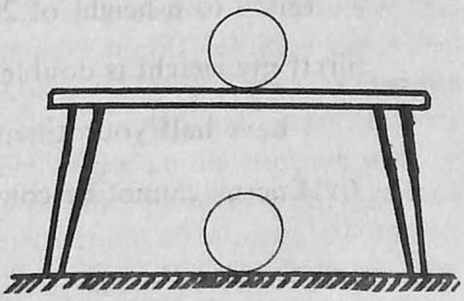


Fig. 6.5 (b)

4. Write the series of energy transformations in the following.

(i) A football kicked up in the air returns to the ground. ____________________

(ii) A ringing electric bell connected to a battery. ____________________

(iii) An athlete running. ____________________

(iv) A moving fan. ____________________

(v) A rocket being fired. ____________________

5. Study the illustrations (Fig. 6.6) and write a list of energy transformations taking place in each.

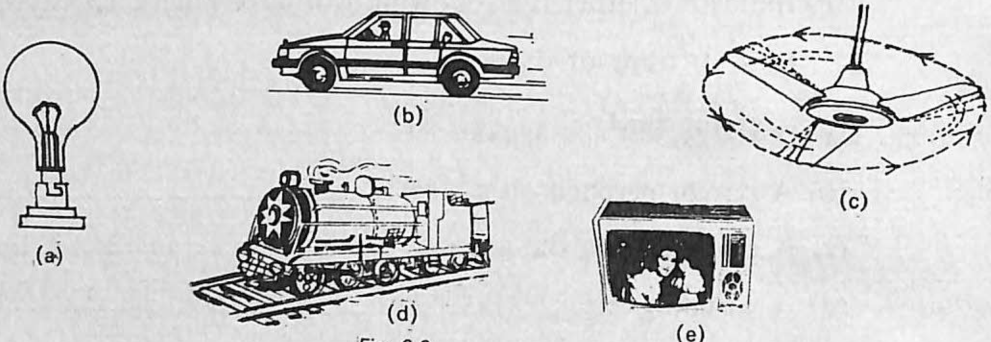


Fig. 6.6

6. (i) From where does the sun derive its power? ____________________

(ii) List three forms of energy besides mechanical energy. ____________________

7. Indicate whether the following statements are true or false.

(i) Work done = Force/Distance.

(ii) A brick raised to a height of 1m has half the potential energy of a brick raised to a height of 2m.

(iii) If my weight is double your weight and you and I run at the same speed, I have half your kinetic energy.

(iv) Energy cannot be converted from one form to another.

7

The Universe

7.1 Stars, Planets and Galaxies

How many times have you looked up in wonder at the tiny dots of light hanging in the night sky? If you have looked carefully enough you may have noticed that most of them twinkle. If you observe them over several nights you will find that though they appear to move from east to west, their position with respect to other stars remains fixed. Such heavenly bodies are called **stars.** They give out their own light. You will also be able to observe other bodies in the sky that do not twinkle. They appear to move not only with respect to the Earth but also with respect to the stars. These are called **planets.** They reflect the light of the Sun that falls on them and do not produce their own light.

You can see nearly 6000 stars on a clear moonless night. Nearly twenty thousand million stars are visible through the most powerful telescope in the world.

Millions of stars and planets form a group known as a **galaxy.** Our Earth, as well as all the stars we can see at night belong to the galaxy called the **Milky Way.** It has a spiral shape and is wider at the centre (Fig. 7.1).

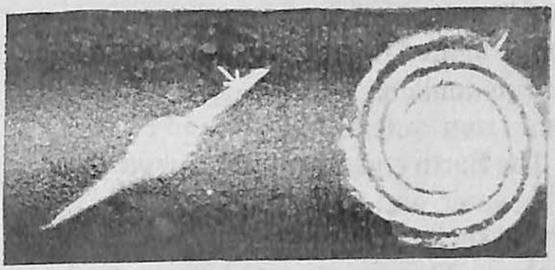


Fig. 7.1 The Milky Way. The arrows show the position of the solar system.

7.2 Astronomical Distances

If you are asked the distance from your house to your school would you say that it is 5,000,000 mm? Certainly not. You would choose a large unit and say that the distance is 5 km. It is therefore much more convenient to use an appropriate unit.

Astronomical distances are so large that the kilometre is not an appropriate unit to measure them. The Proxima Centauri is the nearest star to our Earth next to the Sun.

It is at a distance of approximately 41,000,000,000,000 km. This, as you will realise, is very inconvenient to write. Scientists therefore measure astronomical distances in a unit called the **light year.**

One light year is the distance travelled by light in one year.

Since speed of light = 300,000 km per sec,
1 light year = $300{,}000 \times 365\frac{1}{4} \times 24 \times 3600$ km,
which is approximately, 9,500,000,000,000 km (or 9.5×10^{12} km).

In this unit the distance of Proxima Centauri from the Earth is only 4.3 light years.

7.3 The Earth

The Earth appears flat to us but we know that it is round. At the poles it is flat, so it has the shape of an orange. When seen from outer space it appears to be a huge ball of light. Like the Moon, the Earth also reflects sunlight, and appears to glow when seen from outer space.

The Earth consists of soil, rocks, metals, and water and consists of several shells. These shells are grouped into three main regions. The outermost layer is called the **crust.** The intermediate layer is the **mantle** and the innermost layer is the **core** (Fig. 7.2)

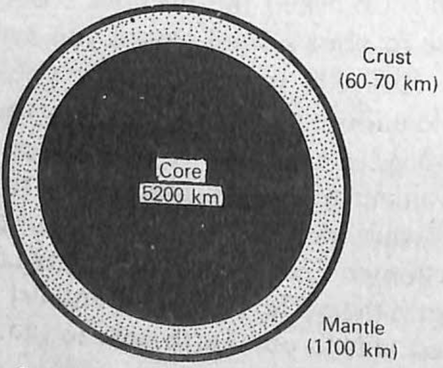


Fig. 7.2 The structure of the Earth.

The diameter of the Earth is about 12,800 km. It is surrounded by an atmosphere of air. The atmosphere mainly consists of nitrogen and oxygen and also contains water vapour and some other gases. It extends to a height of about 300 km. The air becomes lighter as we go up.

Day and Night

The Earth moves all the time. It moves in two different ways. First, it moves round the Sun. Second, it turns round (i.e. it spins) like a top around the axis joining the north and south poles (Fig. 7.3).

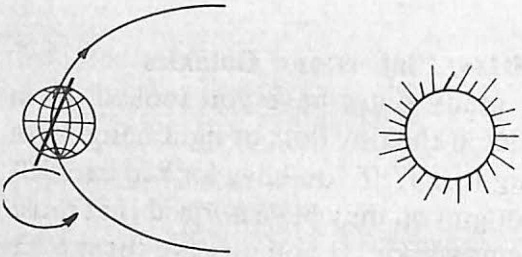


Fig. 7.3 The Earth moves in two ways.

Activity 1: Take a globe or if you cannot get hold of one,a round object such as a ball. Keep it in a dark room. Shine a torch on it from one side. You will notice that light falls on the half facing the torch while the other half is dark (Fig. 7.4). Mark a spot on the globe and rotate it. Notice how the spot moves from the lighted to the dark portion and back.

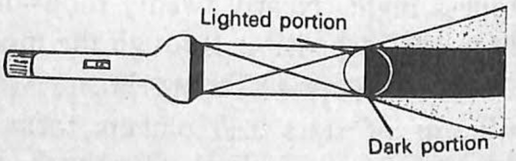


Fig. 7.4

This is exactly how day and night occur on the Earth. As the Earth spins about its axis, light falls on the half facing the Sun and it is day there. The other half which does not receive light is dark and it is night there. As the Earth takes 24 hours to spin once about its axis, one day-night cycle is of 24 hours (Fig. 7.5).

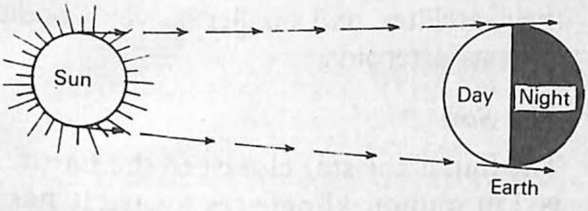


Fig. 7.5 Day and night on the Earth.

Tides

When you throw a stone it falls to the ground. It does not go up or sideways but falls down. This shows that there is a force acting on it in the downward direction. This is known as the **force of gravity**. It is the force with which the Earth pulls an object.

Scientists found that any two objects in this universe attract each other. This force is found to increase with the mass of the objects and decrease with increase in distance between them. The Earth attracts the Moon and the Moon attracts the Earth. It is this force which causes tides to occur in the sea.

Now consider two points A and B on the Earth (Fig 7.6) A is nearer to the Moon and therefore experiences a greater force than B. If the region AB is covered by sea, the water at A will experience greater force than the water at B. Its level at A will rise and A will experience high tide. B will experience low tide.

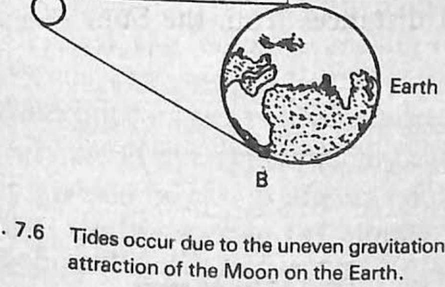


Fig. 7.6 Tides occur due to the uneven gravitational attraction of the Moon on the Earth.

7.4 The Moon

Heavenly objects that revolve around a planet are called **satellites**. The Moon is a natural satellite of the Earth. It is our nearest neighbour and is at an average distance of 384,000 km from the Earth. Being so near it appears much bigger than the stars which are very much further away.

You can clearly see dark patches on the Moon. If you observe the Moon through a telescope you will find that there are large round craters and high mountains on the Moon's surface. The craters look like craters of volcanoes on the Earth. The highest mountain on the Moon is about 10,000 m high—even higher than Mt. Everest. The Moon also has vast plane areas which we call **seas.**

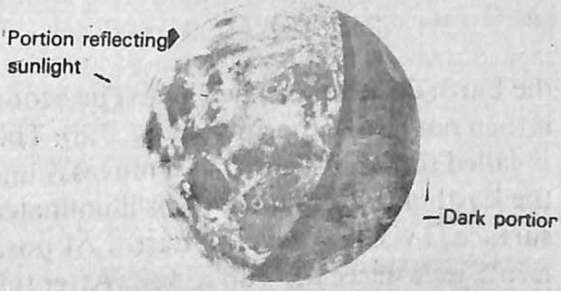


Fig. 7.7 The Moon as seen through the telescope.

The weight of the Moon is one-sixth of the weight of the Earth. Gravity on the Moon is therefore also one-sixth of what it is on the Earth. If on the Earth you can jump to a height of 1.5 m, you can jump to a height of almost 9 m on the Moon!

Because of the low gravity on the Moon, it is not able to retain an atmosphere around it. There is no air on the Moon. The astronauts who go to the Moon therefore carry their own supply of air.

Phases of the Moon

You must have noticed that the size of the Moon appears to change every night. It appears to grow from a thin curve to a full circle in about two weeks and then slowly reduces to disappear completely in another two weeks. These changes are called **phases** of the Moon.

The size of the Moon does not of course change. What changes is the area of the Moon that is visible to us due to reflected sunlight (Fig. 7.7). When the Moon is between the Sun and the Earth the side facing the Earth does not receive light. The Moon is then not visible (position 1 Fig. 7.8). This is called the New Moon. As it moves round the Earth more and more of its illuminated surface is visible from the Earth. At position 5 we can see the Full Moon. After this the visible illuminated surface again decreases.

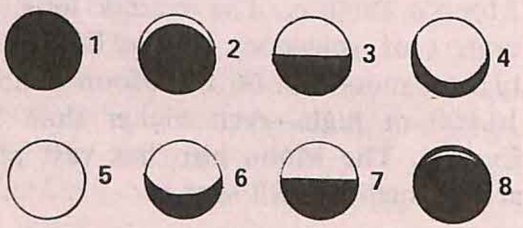


Fig. 7.8 Phases of the Moon.

The phases of the Moon repeat after every 29 days as it takes the Moon approximately 29 days to orbit the Earth once.

Man reached the Moon for the first time on 21st July 1969 when two American astronauts, Neil Armstrong and Edwin Aldrin landed on the Moon. The Moon trip has been repeated since then.

7.5 The Solar System

The solar system consists of the Sun and all the heavenly bodies that move around the Sun, such as the nine planets along with their satellites, and smaller heavenly bodies such as asteroids.

The Sun

The Sun is the star closest to the Earth. It is 150 million kilometres away. It has a diameter of about 1,392,000 km which is almost 110 times the diameter of the Earth (Fig. 7.9). The centre of the Sun is very hot. It has a temperature of around 14 million°C. It gives out large amounts of heat and light. A small part of it is received on the Earth.

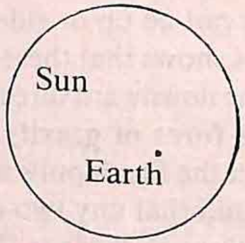


Fig. 7.9 Relative size of Sun and Earth.

The Planets

Nine planets, including the Earth, revolve around the Sun in elliptical orbits (Fig. 7.10). They are of various sizes and at different distances from the Sun.

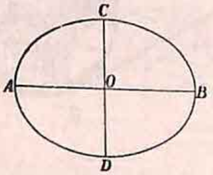


Fig. 7.10 (a) An ellipse.

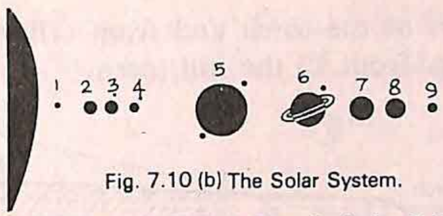


Fig. 7.10 (b) The Solar System.

1. Mercury 2. Venus 3. Earth 4. Mars 5. Jupiter 6. Saturn 7. Uranus 8. Neptune 9 Pluto

Table 7.1 The planets; their diameters and distances from the Sun.

Planet	Distance from the Sun (Million km)	Diameter (km)
1. Mercury	58	4880
2. Venus	108	12100
3. Earth	150	12756
4. Mars	228	6790
5. Jupiter	778	142800
6. Saturn	1427	120000
7. Uranus	2870	5100
8. Neptune	4497	4900
9. Pluto	5900	3000

Fig. 7.10b shows the nine planets and their orbits around the Sun. Table 7.1 gives the diameters and the distances of these planets from the Sun.

Mercury is the planet closest to the Sun. It is small and does not have any atmosphere.

Venus is the planet closest to the Earth. It is visible after sunset and before dawn. Hence it is known as the 'evening' or the 'morning' star. It is about the same size as the Earth.

Earth seems to be the only planet with life on it. All the factors necessary for life are present only on the Earth.

Mars appears as a reddish planet in the sky.

Jupiter (Fig. 7.11) is the largest planet. It is covered by clouds and an enormous red spot can be seen in the clouds.

Saturn (Fig. 7.12) is seen as a bright yellow planet. It has several rings around it which consist of particles, possibly of ice.

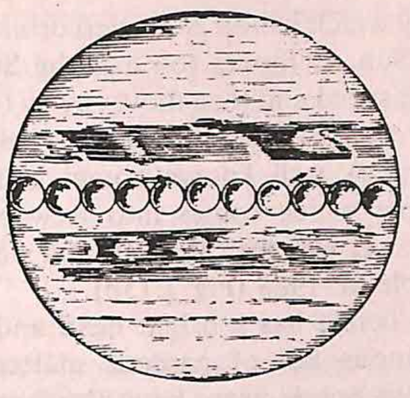


Fig. 7.11 Jupiter with Earth to scale.

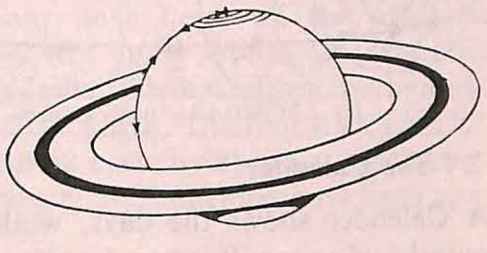


Fig. 7.12 Saturn and its rings.

Uranus is a large planet very far away from the Sun and the Earth. It is a very cold planet.

Neptune and Pluto are very far off and can only be seen through a telescope. Pluto is the farthest planet from the Sun.

7.6 Comets

A comet (Fig 7.13a) is an irregular heavenly

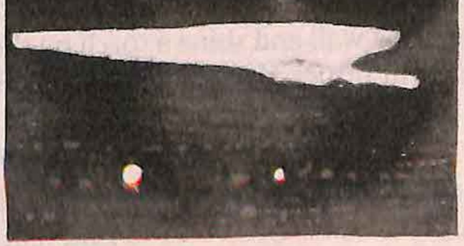


Fig. 7.13 (a) A comet

body which has an elongated orbit around the Sun. It moves towards the Sun with great speed and then moves away to disappear. It may again come back after several years. A well known comet is Halley's Comet which comes into view every 76 years. It was seen in 1910 and was again visible in 1986 (Fig 7.13b).

A comet has a bright head and a long luminous tail of gaseous matter which always points away from the Sun.

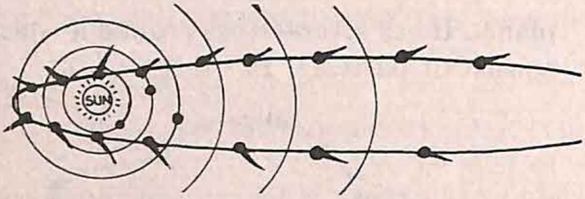


Fig. 7.13 (b) Orbit of Halley's comet.

7.7 The Calendar

A Calender shows the days, weeks and months of a year. It is based on the movement of the Earth around the Sun. One year is the time the Earth takes to go round the Sun. However, the Earth takes 365¼ days to go once round the Sun, but we take one year to be of 365 days To compensate for the loss of ¼ day, we add one day to the year after every four years. This particular year is of 366 days and is known as a **leap year**. In a normal year February has 28 days. In a leap year it has 29 days.

7.8 Eclipses

Activity 2: In a dark room place a ball in front of a wall and shine a torch on the ball. You will notice that a shadow of the ball will be formed on the wall (Fig. 7.14). Keep your eyes in the region of the shadow (e.g. at A). Can you now see the torch? Move your eyes sideways. You will find that from some places (e.g. from B), you can see a part of the torch and from other places (e.g. from C) the full torch.

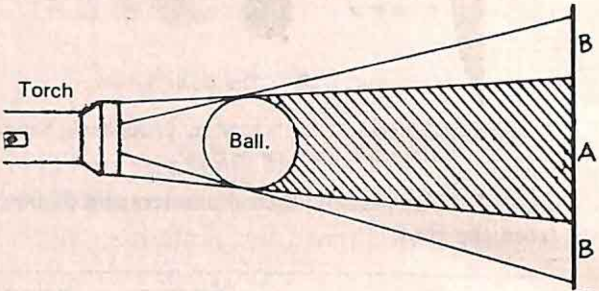


Fig. 7.14

Similarly, when the Sun shines on the Earth or the Moon, they cast shadows. If the shadow of the Moon falls on the Earth, we can either not see the Sun at all, or we can see it only partially, depending on our position on the Earth (Figure 7.15). Thus when the Sun, the Moon and the Earth come in one straight line, with the Moon between the Sun and Earth, the shadow of the Moon may fall on the Earth. We will then observe a **solar eclipse.** A full solar eclipse will be observed at *a*, a partial eclipse at *b* and no eclipse at *c*.

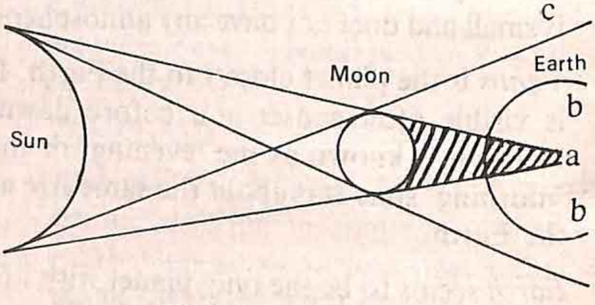


Fig. 7.15 Solar eclipse.

A solar eclipse can only occur on a new Moon day. Can you say why?

Eclipse of the Moon occurs on a particular full Moon day when the Earth is between the Sun and the Moon. In this condition the shadow of the Earth falls on the

Moon. The eclipse may be total or partial, depending on the position of the Moon (Fig. 7.16).

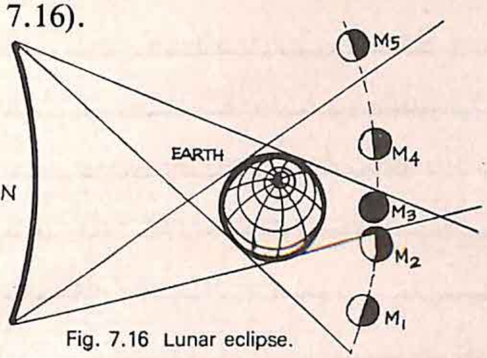


Fig. 7.16 Lunar eclipse.

7.9 Pole Star

Careful observations of the movement of stars relative to the Earth has shown that all stars appear to go around the Pole Star once in 24 hours. The Pole Star, however, remains almost stationary in position.

The Pole Star is directly above the North Pole, on the axis of rotation of the Earth. It therefore does not move relative to the Earth.

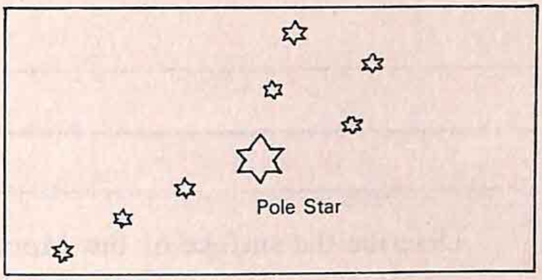


Fig. 7.17 Position of the Pole Star

The stars which seem to go around the Pole Star do not actually move. They only appear to move because of the rotation of the Earth. They appear to move around the axis of rotation of the Earth, and therefore around the Pole Star.

7.10 Artificial Satellites

You may have heard of the artificial satellites sent up by several countries, including India. These satellites continuously orbit the Earth. The first such satellite was Sputnik 1 sent by Russia in 1957. Since then thousands of satellites have been sent up.

The Indian satellite INSAT 1B helps us in predicting the weather, in transmitting television programmes and in establishing telephone links throughout our country.

EXERCISES

1. How can you distinguish between a planet and a star while looking at the sky with the naked eye? ______________________________

____

____

____

Why do planets appear bright even when they do not produce any light of their own? ______________________________

____

3. Describe the surface of the Moon.

4. What causes the apparent change in the size of the Moon every night?

5. Name the planets in order of increasing distances from the Sun.

6. Name the important astronomical happening in 1986.

7. Why is it that in a leap year, February has 29 days?

8. Fill in the blanks.

(i) Our Earth belongs to the galaxy known as ________________

(ii) Tides are caused because of the force of ________________ between the Earth and the ________________ .

(iii) The Moon is a ________________ satellite of the Earth.

INSAT IB is a ________________ satellite of the Earth.

(iv) ________________ is the only star which appears stationary to us.

(v) The planet closest to the Sun is ________________

(vi) The planet farthest from the Sun is ________________ .

(vii) The largest planet is ________________ .

(viii) The smallest planet is ________________ .

(ix) A lunar eclipse can only occur on a ________________ Moon day.

(x) A solar eclipse can only occur on a ________________ Moon day.

9. Write True or false.

(i) Planets do not produce their own light

(ii) A light year is the distance travelled by sound in one year.

(iii) Day and night are caused by the rotation of the Earth around the Sun.

(iv) The Moon is bigger than most stars in the sky.

(v) If you weigh 36 kg on the Earth you would weigh 6 kg on the Moon.

(vi) The Moon is not visible on a New Moon day.

(vii) On a Full Moon day, the Moon is between the Earth and the Sun.

(viii) Eclipses are caused because of shadows.

(ix) All stars actually move around the Pole Star.

(x) Television programmes are broadcast to various cities in India through the satellite INSAT IB.

Understanding Science

Physics - Classes 6, 7 & 8
Chemistry - Classes 6, 7 & 8
Biology - Classes 6, 7 & 8

This series of nine books is planned according to the guidelines set by the NCERT, but caters to the needs of the ICSE syllabus as well. The approach is modern, yet simple. The important concepts, scientific terms and definitions have been highlighted to help the student to remember them easily. Concepts have been formed with the aid of innovative experiments so that learning becomes an enjoyable experience rather than a tedious ritual. The students can perform the experiments on their own with readily available apparatus. Each chapter has an extensive workbook section containing mainly short-answer and objective type questions.

Sangam Books

Ummat, Bhargava & Chhaya : UNDERSTANDING SCIENCE PHYSICS Class VI
ISBN 0 86131 653 3

Rs. 11.50